Identification of Evaporation/Wind, Evaporation/SST and Evaporation/ Air Humidity Regimes in the Southern Ocean from Satellite Data

Joy Romanski[1], Anastasia Romanou[2], William B. Rossow[3]

March 17, 2010

[1]Sigma Space Partners, LLP, NASA GISS
[2]NASA GISS, Columbia University
[3]City College of New York, CUNY

Photo: Commonwealth of Australia

Overview

- What are flux regimes? Why do we care about them?
- Why use satellite data?
- Where do the GSSTF2b and HOAPS3 variables come from?
- Climatology of fluxes and state variables from each dataset
- Cluster analysis method, and preliminary results
- Future directions

Where do the fluxes come from?

$$F_{LH} = \rho_a L_e C_e U_{10} (q_s - q_a)$$

Where do the fluxes come from?

$$F_{LH} = \rho_a L_e C_e U_{10} (q_s - q_a)$$

- $\mathbf{U_{10}}$ =10 m wind speed (m/s)

  HOAPS3 - SSM/I neural network retrieval

  GSSTF2b - Wentz V6 SSM/I inverse radiative transfer model

Where do the fluxes come from?

$$F_{LH} = \rho_a L_e C_e U_{10} (q_s - q_a)$$

- $\mathbf{U_{10}}$ =10 m wind speed (m/s)

  HOAPS3 - SSM/I neural network retrieval

  GSSTF2b - Wentz V6 SSM/I inverse radiative transfer model

- $\mathbf{q_s}$ = Sea surface specific humidity (g/kg), derived from SST, with correction for salinity

  HOAPS3 - NODC/RSMAS AVHRR Oceans Pathfinder SST v5.0 product

  GSSTF2b - NCEP DOE Reanalysis V2 blended in situ and satellite (AVHRR) weekly product

Where do the fluxes come from?

$$F_{LH} = \rho_a L_e C_e U_{10} (q_s - q_a)$$

- $\mathbf{U_{10}}$ =10 m wind speed (m/s)

  HOAPS3 - SSM/I neural network retrieval

  GSSTF2b - Wentz V6 SSM/I inverse radiative transfer model

- $\mathbf{q_s}$ = Sea surface specific humidity (g/kg), derived from SST, with correction for salinity

  HOAPS3 - NODC/RSMAS AVHRR Oceans Pathfinder SST v5.0 product

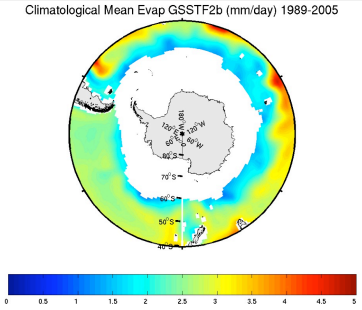
  GSSTF2b - NCEP DOE Reanalysis V2 blended in situ and satellite (AVHRR) weekly product

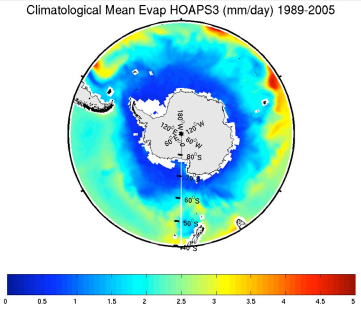
- $\mathbf{q_a}$ = Air (10 m) specific humidity (g/kg)

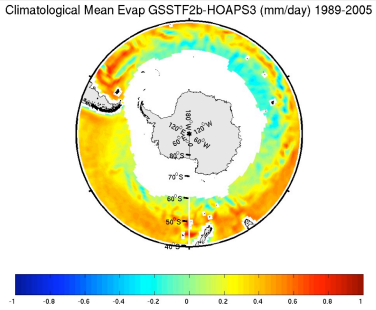
  HOAPS3 - linear combination of SSM/I radiances

  GSSTF2b - EOFs relating 10m air humidity to SSM/I derived total column and bottom layer precipitable water

Climatological Mean Fields

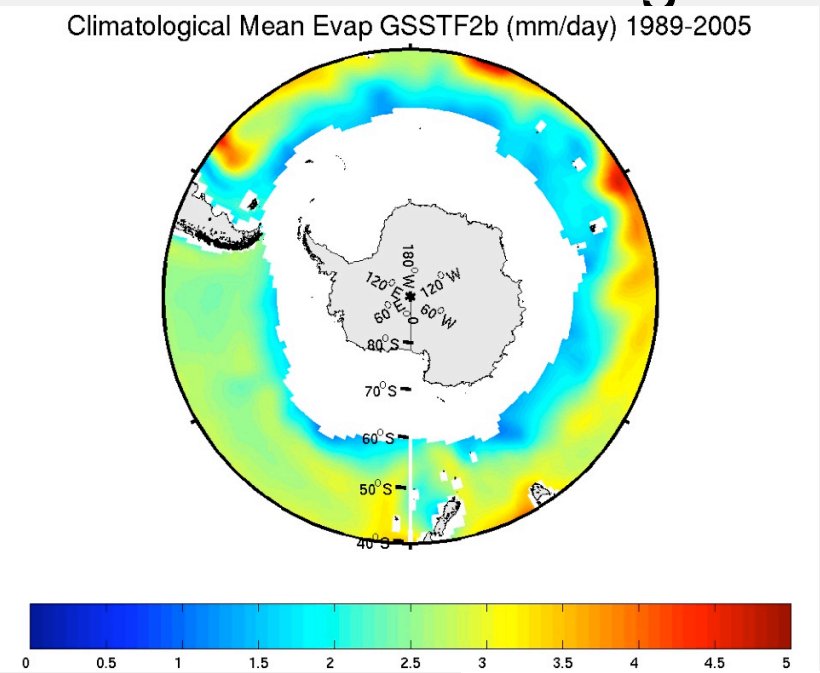


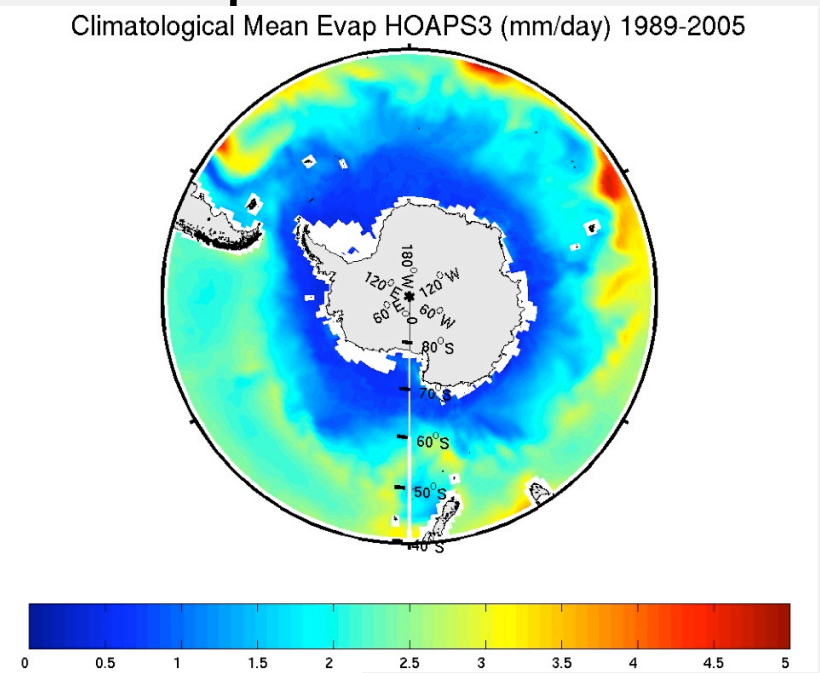


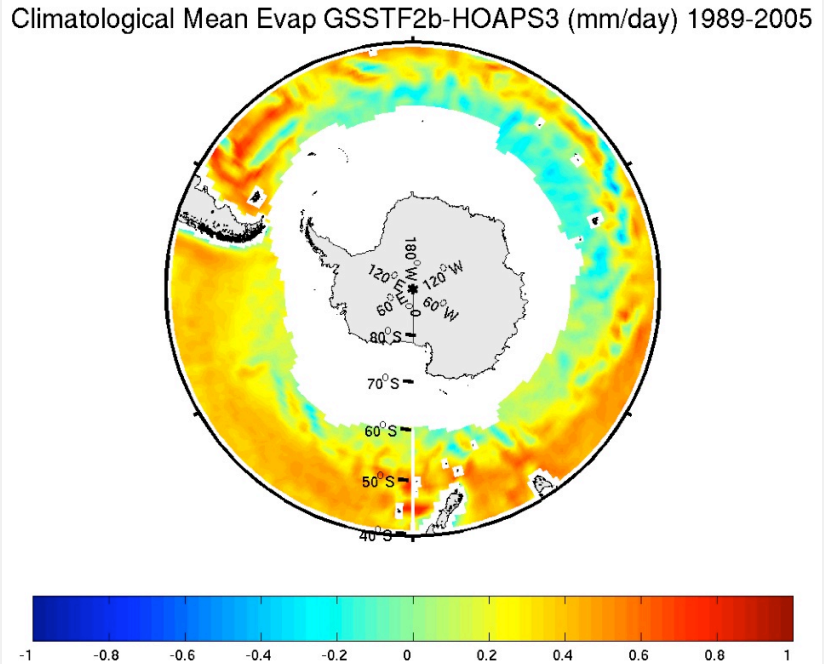


GSSTF2b evap higher, seasonally invariant ice mask

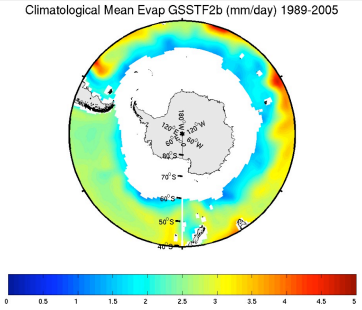
Climatological Mean Evaporation

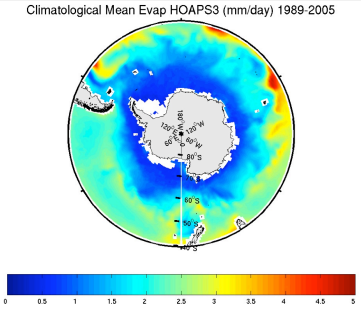


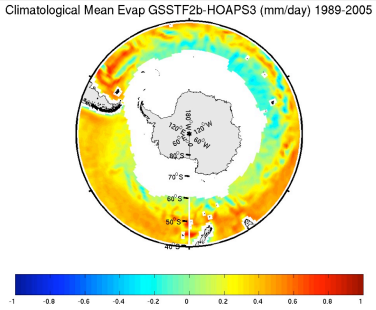




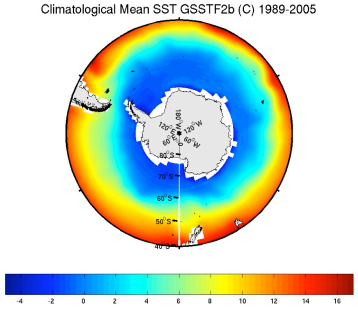
Climatological Mean Fields

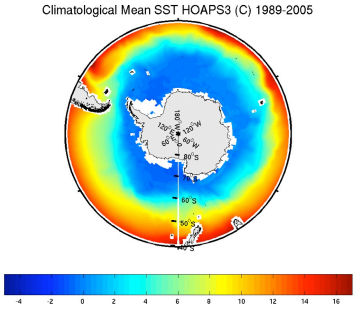


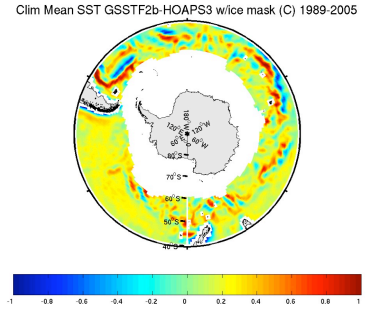




GSSTF2b evap higher, seasonally invariant ice mask

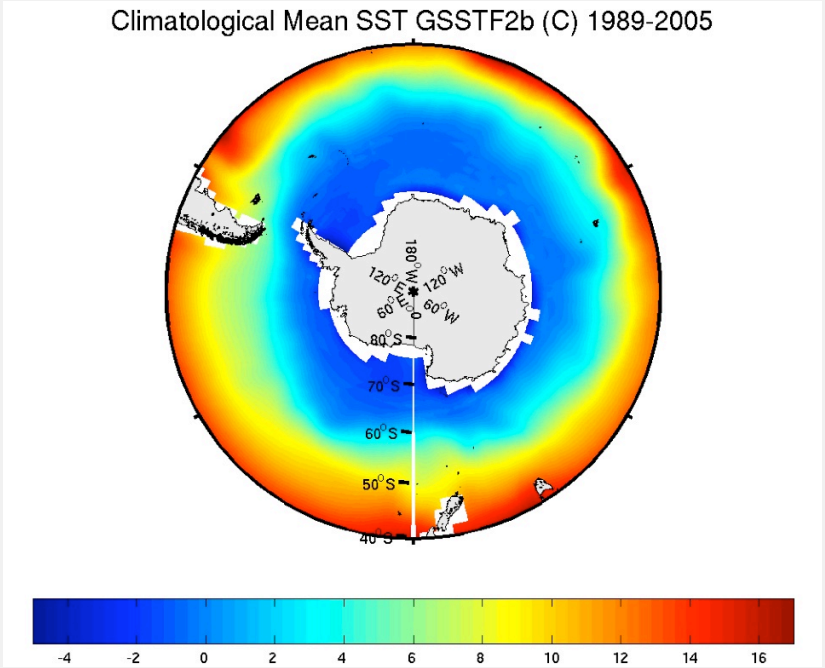


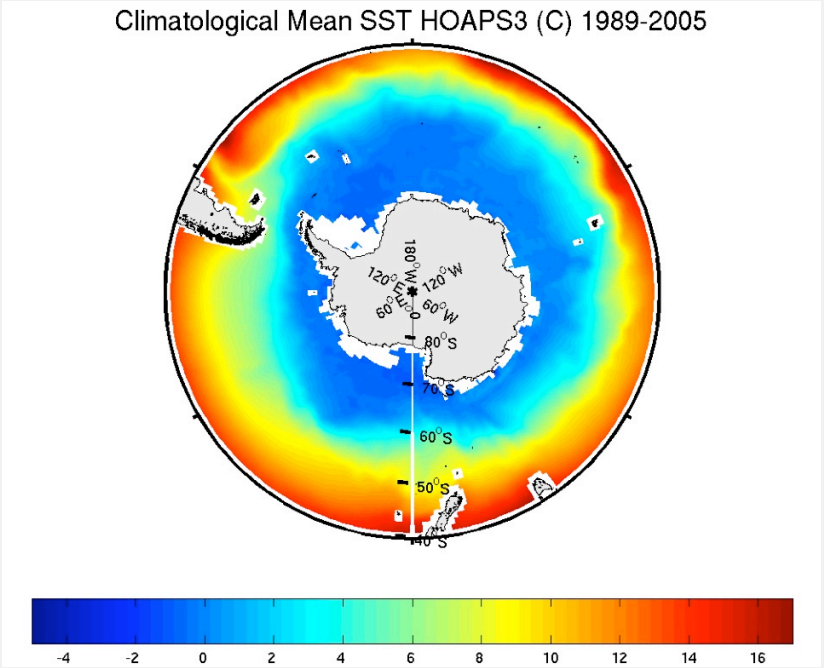


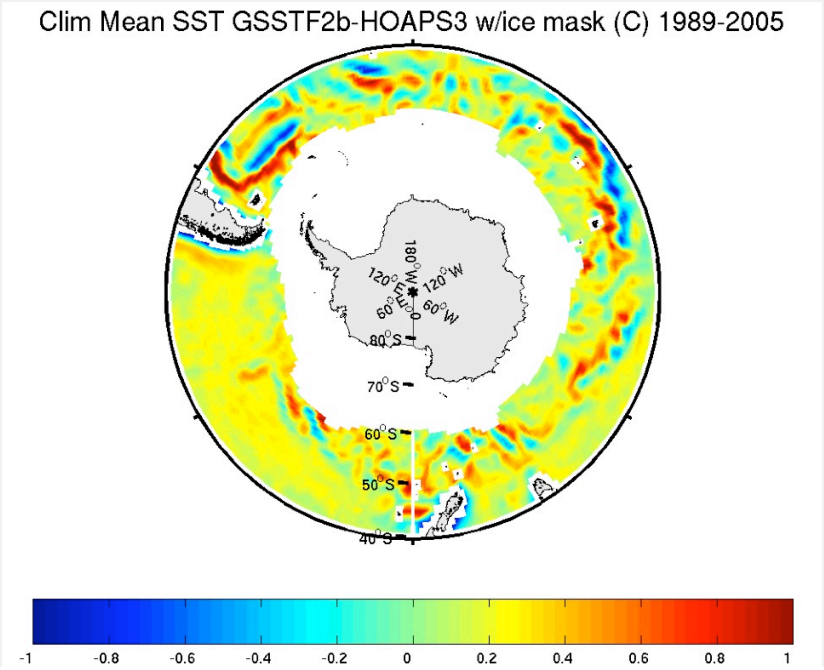


GSSTF2b SST warmer, HOAPS3 has more small scale structure

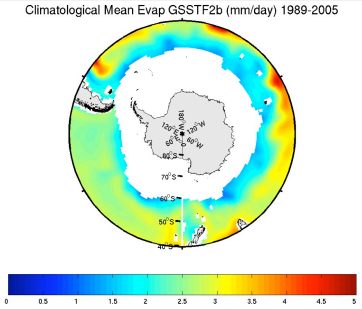
Climatological Mean SST

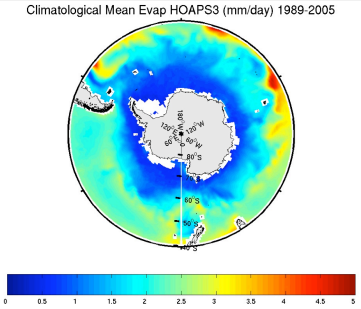


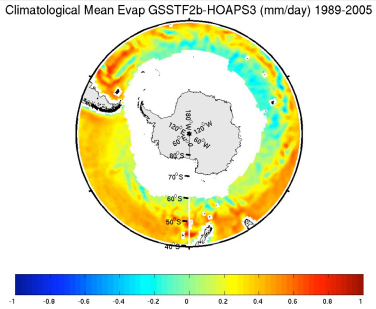




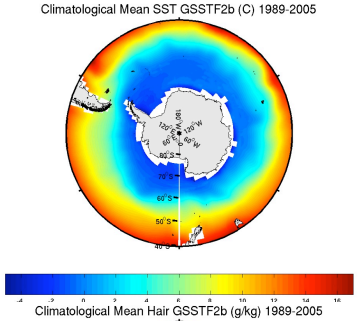
Climatological Mean Fields

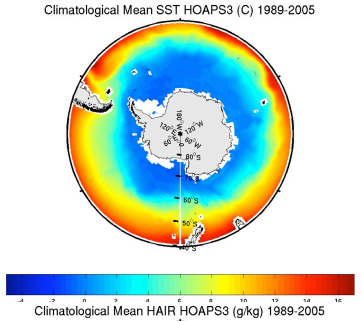


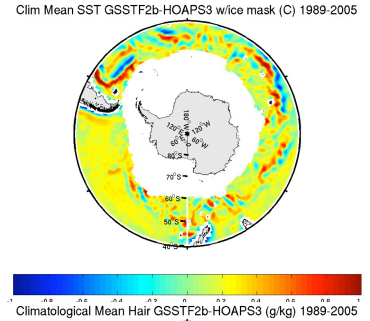




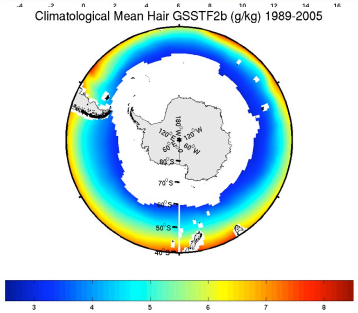
GSSTF2b evap higher, seasonally invariant ice mask

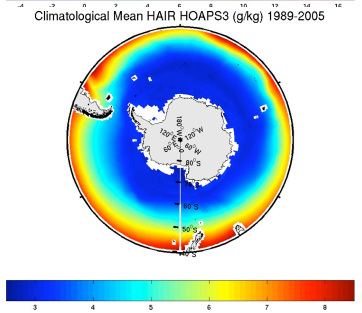


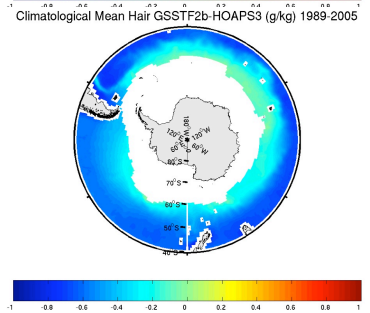




GSSTF2b SST warmer, HOAPS3 has more small scale structure

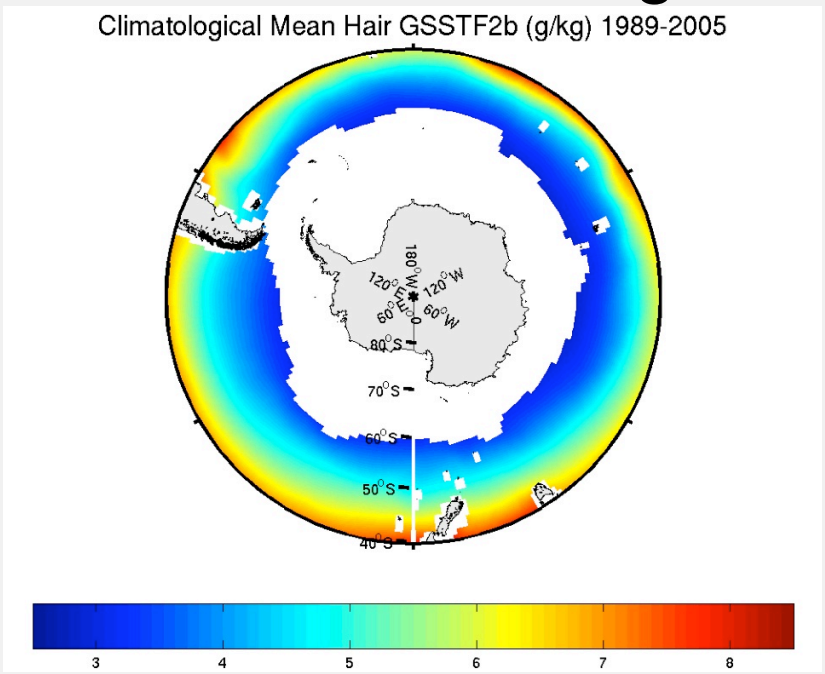


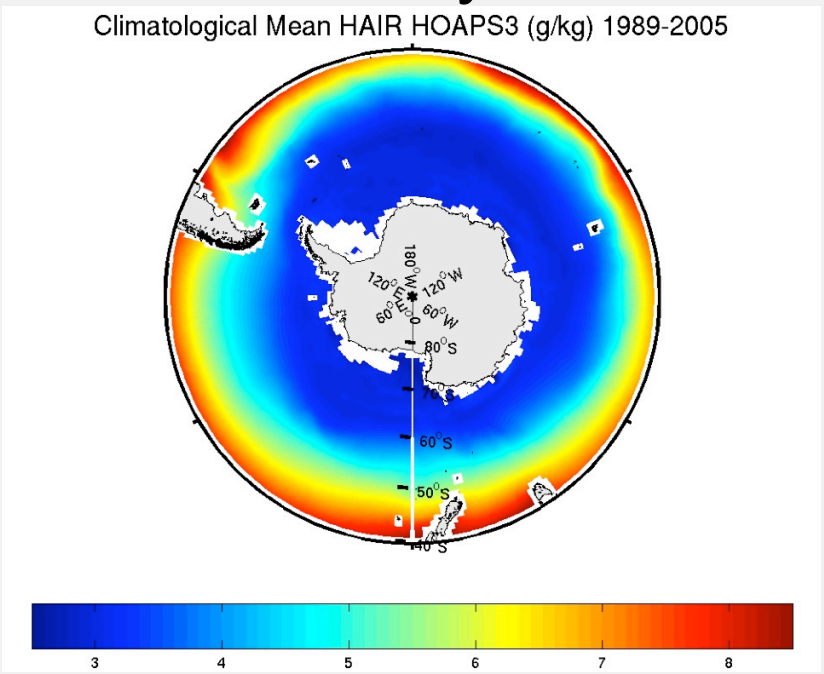


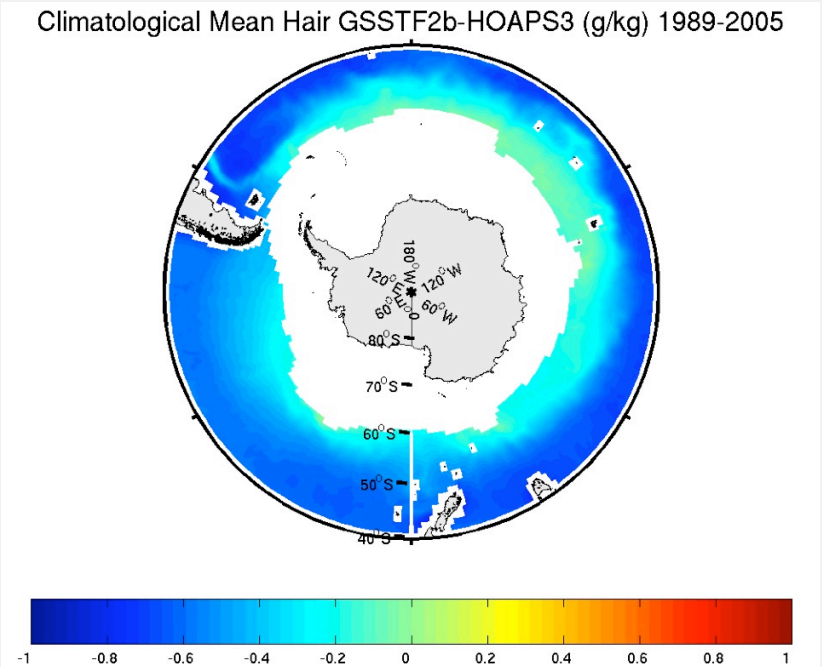


GSSTF2b drier, seasonally invariant ice mask

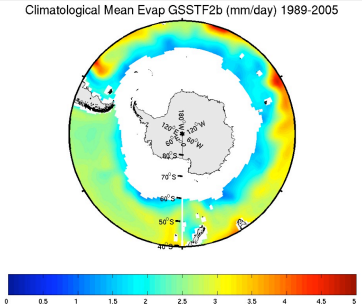
Climatological Mean Air Humidity

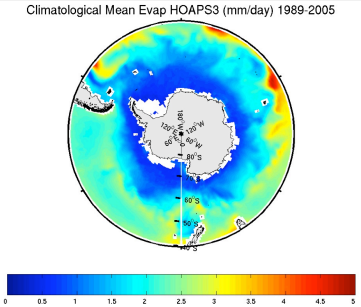


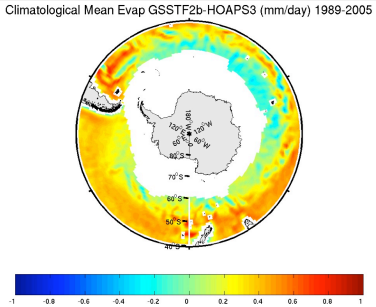




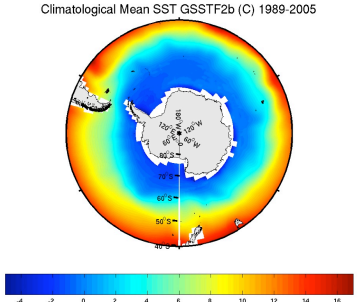
Climatological Mean Fields

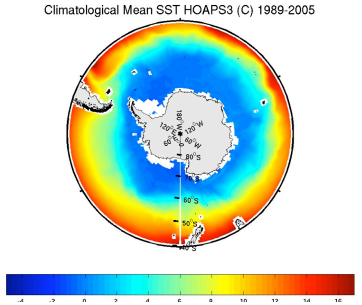


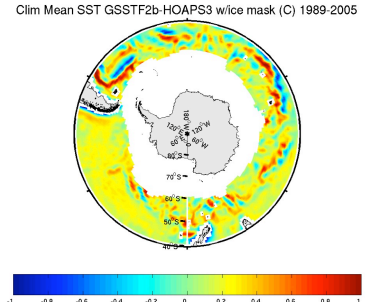




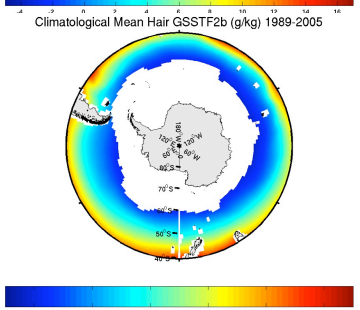
GSSTF2b evap higher, seasonally invariant ice mask

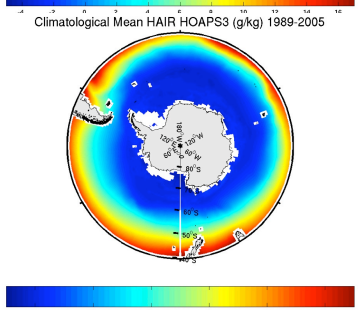


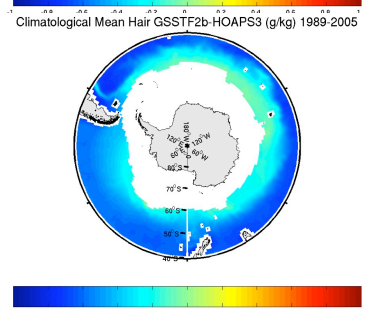




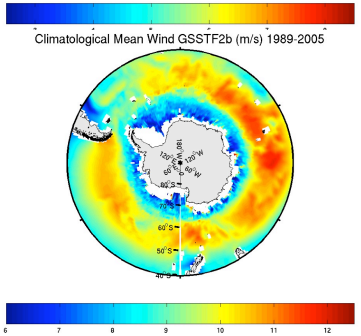
GSSTF2b SST warmer, HOAPS3 has more small scale structure

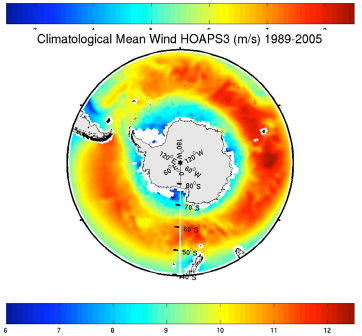


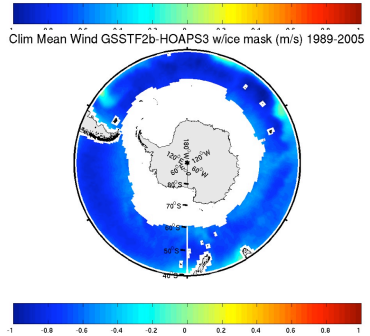




GSSTF2b drier, seasonally invariant ice mask

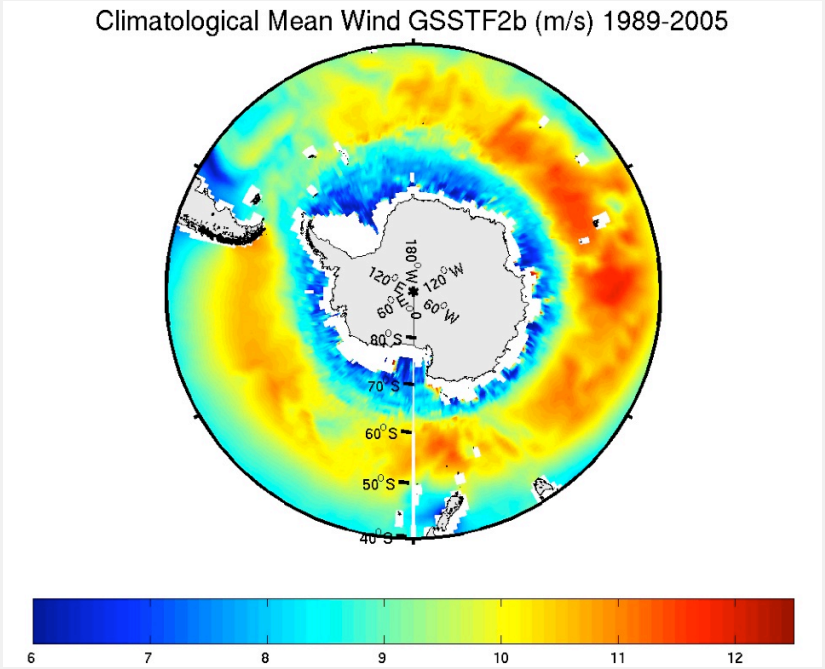


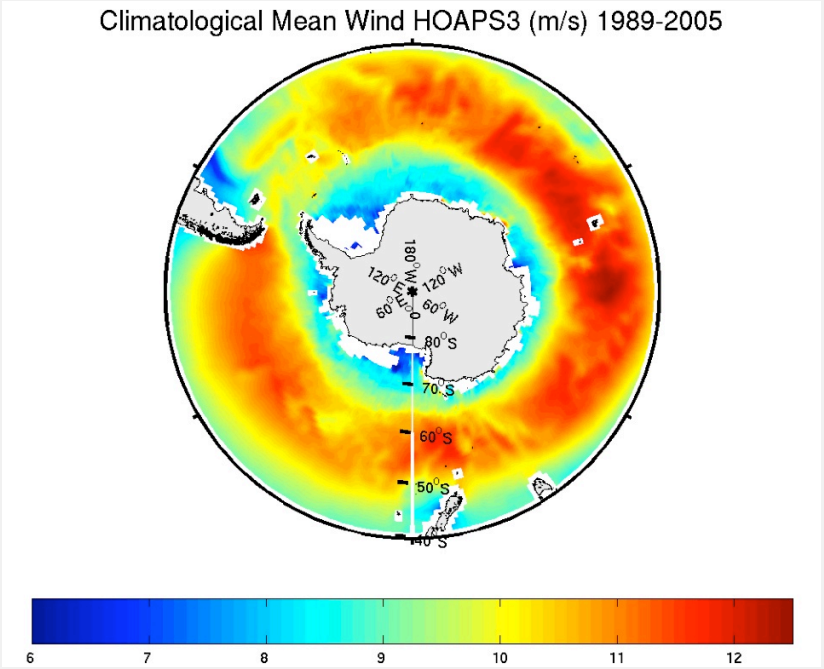


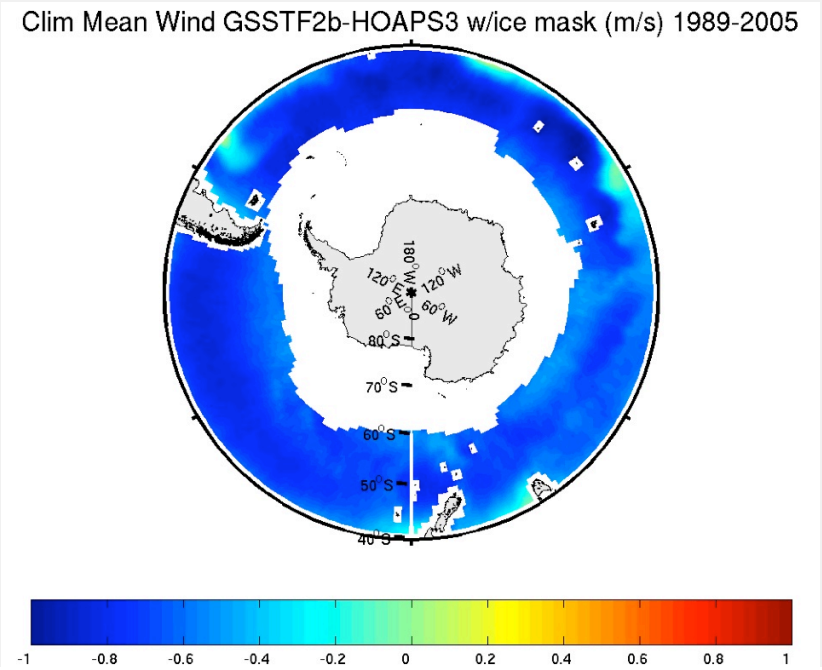


HOAPS3 windier

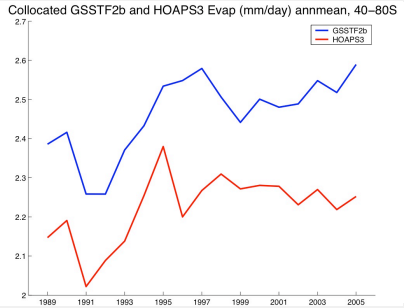
Climatological Mean Winds





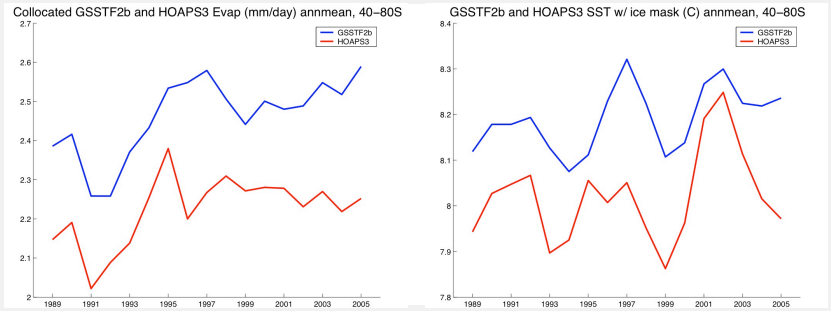


Interannual Variability



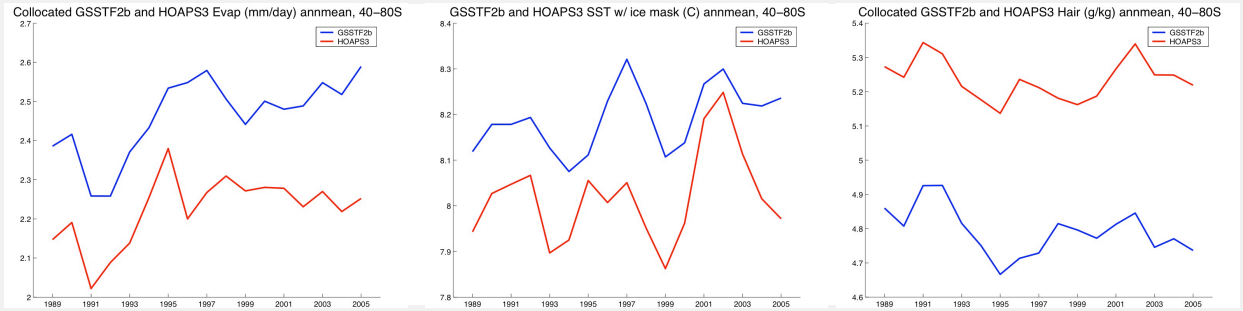
- HOAPS3 and GSSTF2b evap have opposite sign trends post-1999

Interannual Variability



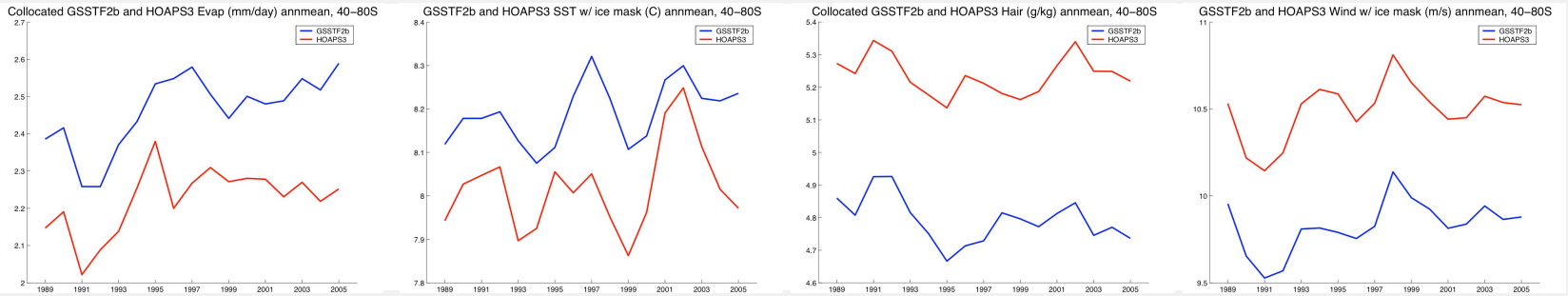
- HOAPS3 and GSSTF2b evap have opposite sign trends post-1999
- GSSTF2b has upward trend in SST and consistent interannual variability over entire period, HOAPS3 has downward trend until 1999, then large interannual variability

Interannual Variability



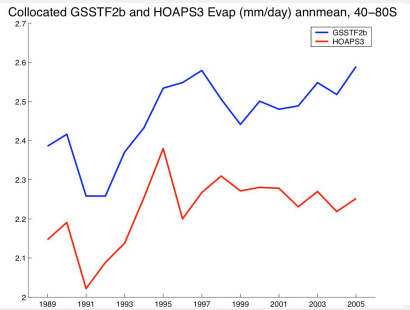
- HOAPS3 and GSSTF2b evap have opposite sign trends post-1999
- GSSTF2b has upward trend in SST and consistent interannual variability over entire period, HOAPS3 has downward trend until 1999, then large interannual variability
- HOAPS3 and GSSTF2b have opposite sign trends post-1999

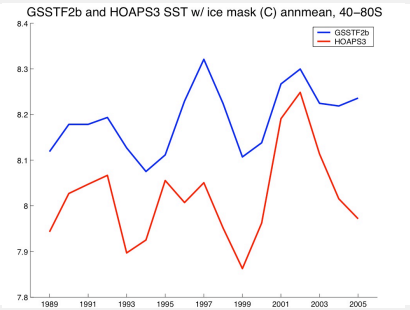
Interannual Variability

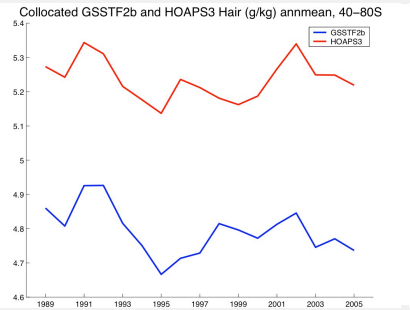


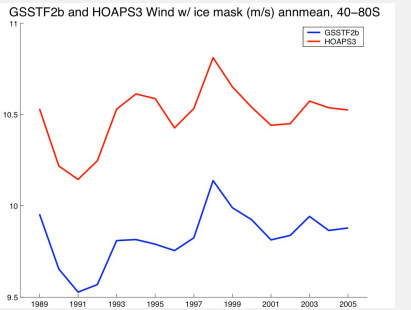
- HOAPS3 and GSSTF2b evap have opposite sign trends post-1999
- GSSTF2b has upward trend in SST and consistent interannual variability over entire period, HOAPS3 has downward trend until 1999, then large interannual variability
- HOAPS3 and GSSTF2b have opposite sign trends post-1999
- Interannual variability of wind fields is similar

Interannual Variability





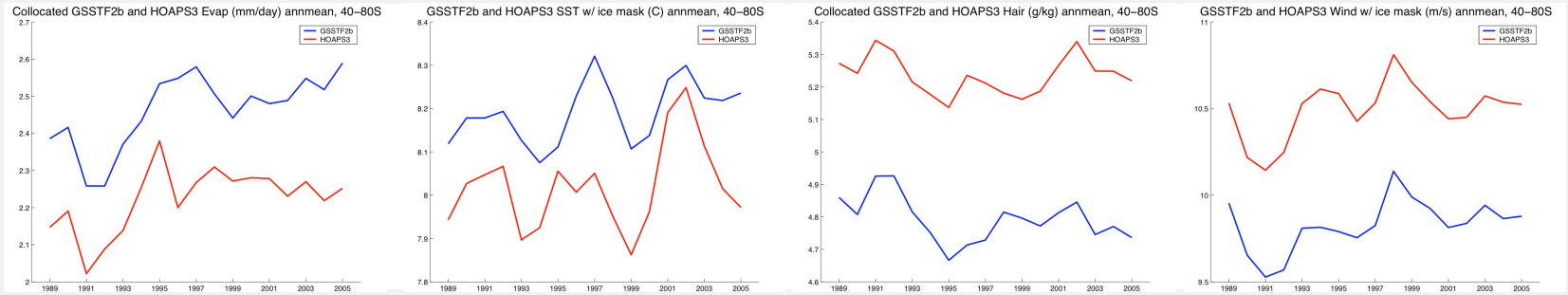




- HOAPS3 and GSSTF2b evap have opposite sign trends post-1999
- GSSTF2b has upward trend in SST and consistent interannual variability over entire period, HOAPS3 has downward trend until 1999, then large interannual variability
- HOAPS3 and GSSTF2b have opposite sign trends post-1999
- Interannual variability of wind fields is similar

Large interannual variability in SST not apparent in evap

Interannual Variability

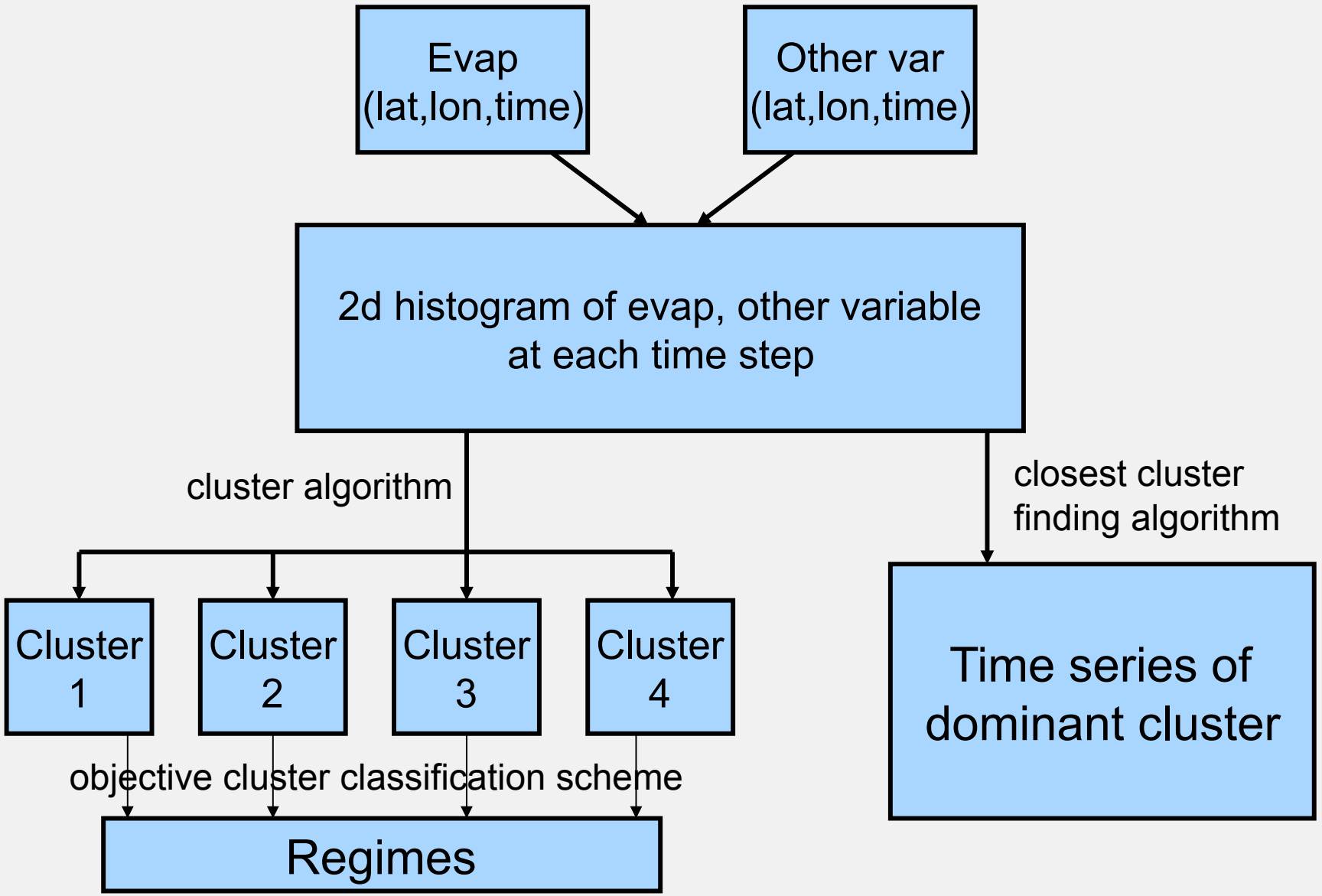


- HOAPS3 and GSSTF2b evap have opposite sign trends post-1999
- GSSTF2b has upward trend in SST and consistent interannual variability over entire period, HOAPS3 has downward trend until 1999, then large interannual variability
- HOAPS3 and GSSTF2b have opposite sign trends post-1999
- Interannual variability of wind fields is similar

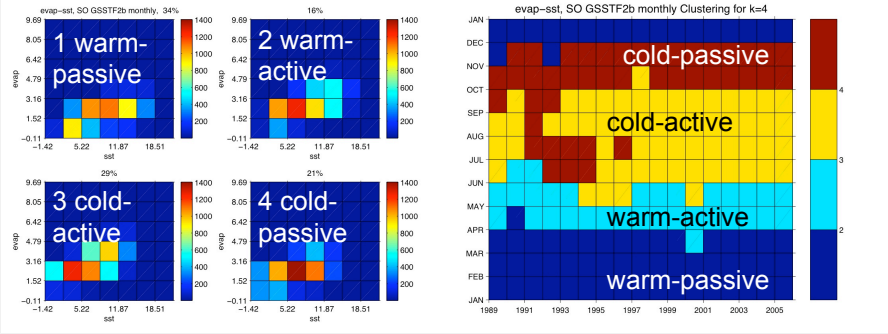
Large interannual variability in SST not apparent in evap

Different sign trend in evap post-1999 due mainly to differences in air humidity trends

Cluster Analysis Methodology

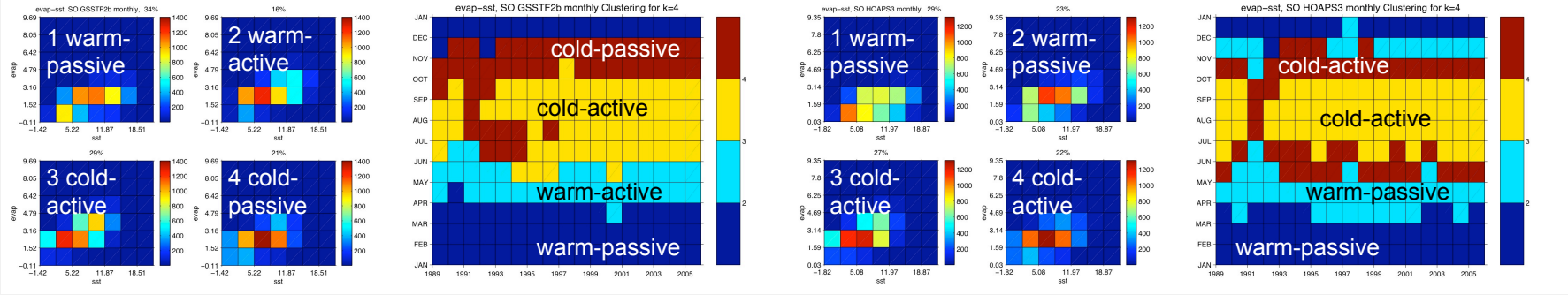


Cluster Analysis Results



GSSTF2b has 4 seasonal modes, winter and summer do not show expected relationship between evap and SST

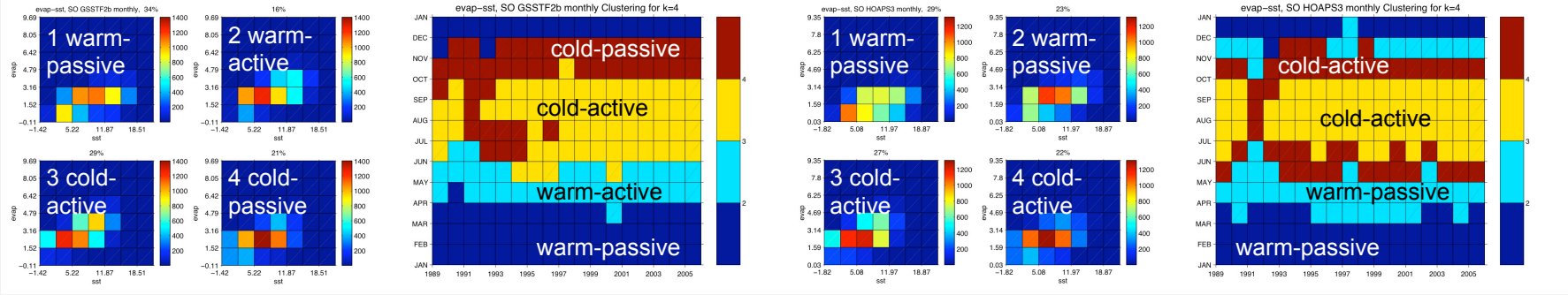
Cluster Analysis Results



GSSTF2b has 4 seasonal modes, winter and summer do not show expected relationship between evap and SST

HOAPS3 has only 2 modes, neither shows expected relationship between evap and SST

Cluster Analysis Results

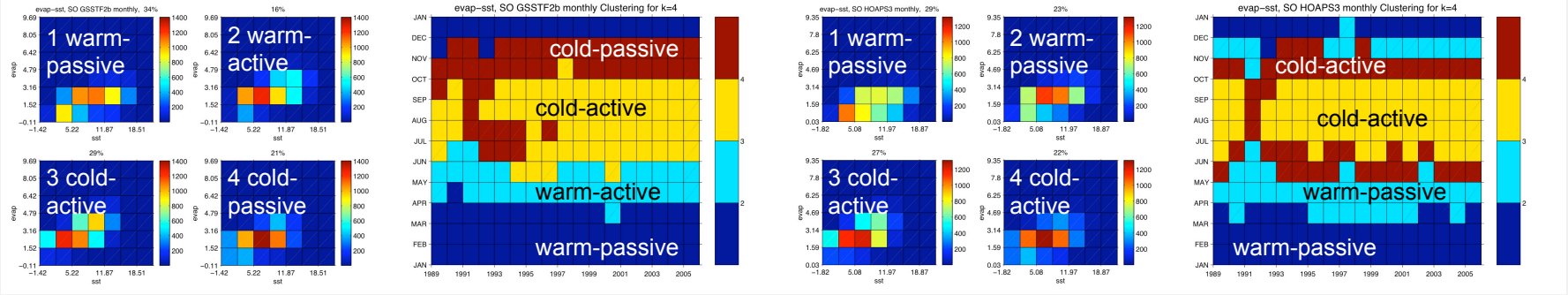


GSSTF2b has 4 seasonal modes, winter and summer do not show expected relationship between evap and SST

HOAPS3 has only 2 modes, neither shows expected relationship between evap and SST

SST is not directly driving evaporation *in this region*

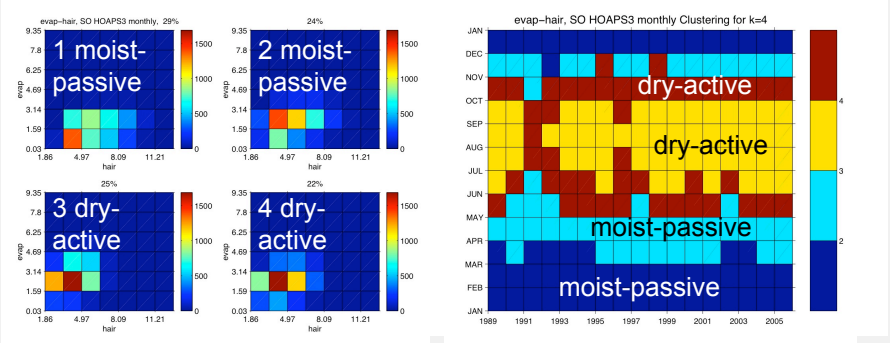
Cluster Analysis Results



GSSTF2b has 4 seasonal modes, winter and summer do not show expected relationship between evap and SST

HOAPS3 has only 2 modes, neither shows expected relationship between evap and SST

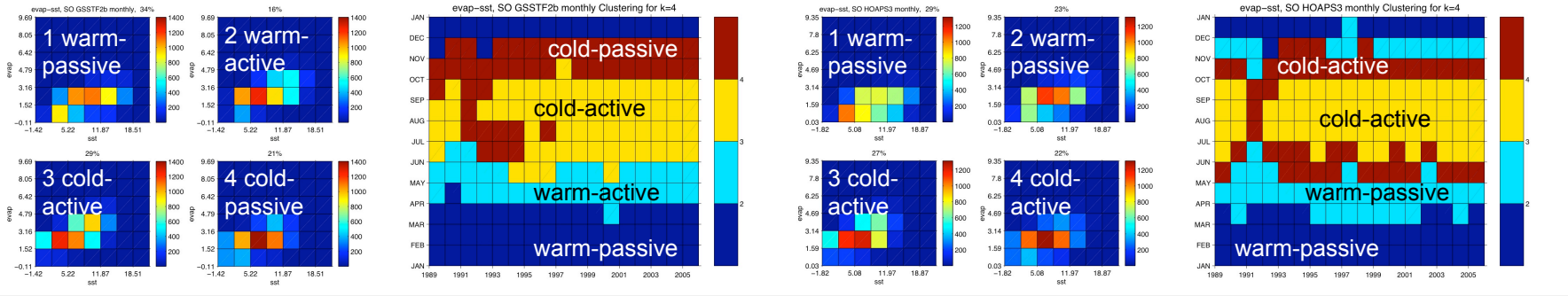
SST is not directly driving evaporation *in this region*



2 seasonal modes which show expected relationship with evap

GSSTF2b clusters, time variation are nearly identical

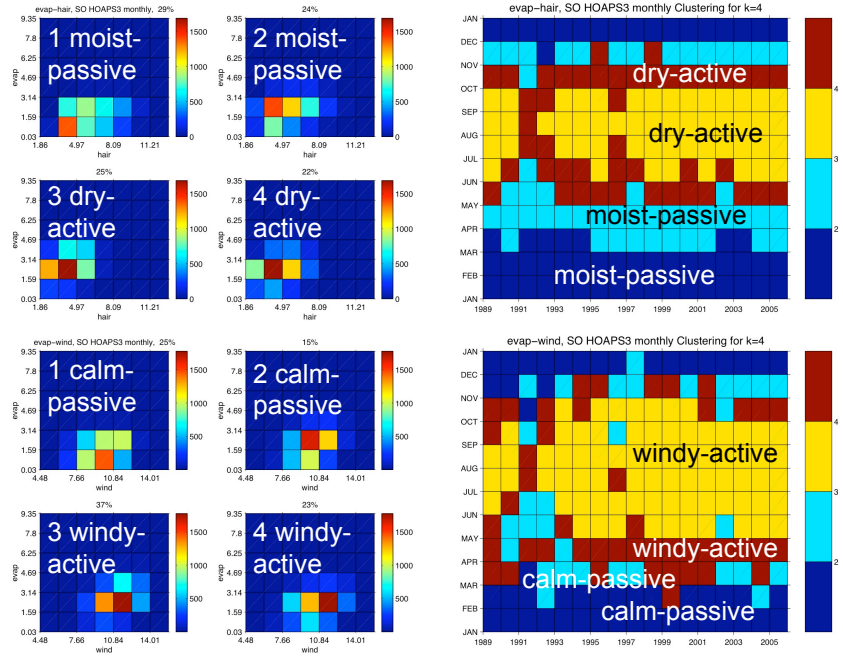
Cluster Analysis Results



GSSTF2b has 4 seasonal modes, winter and summer do not show expected relationship between evap and SST

HOAPS3 has only 2 modes, neither shows expected relationship between evap and SST

SST is not directly driving evaporation *in this region*



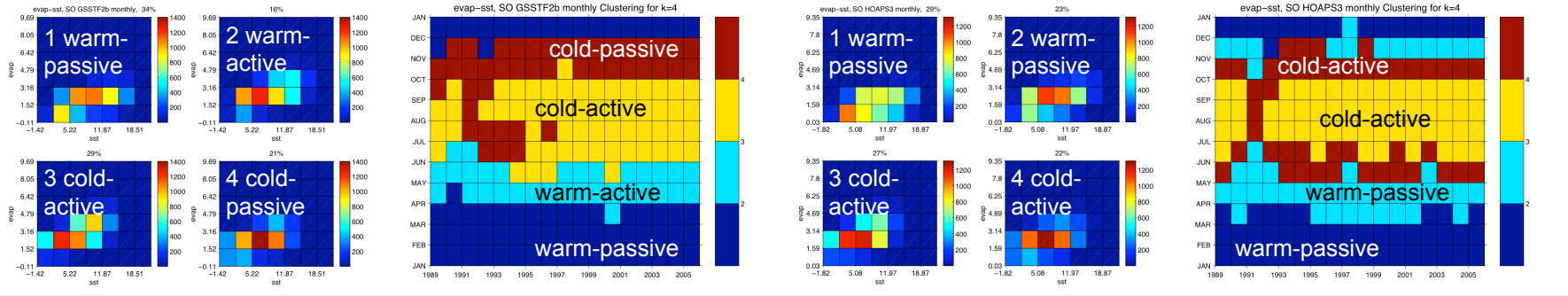
2 seasonal modes which show expected relationship with evap

GSSTF2b clusters, time variation are nearly identical

2 seasonal modes which show expected relationship with evap

GSSTF2b clusters, time variation are nearly identical

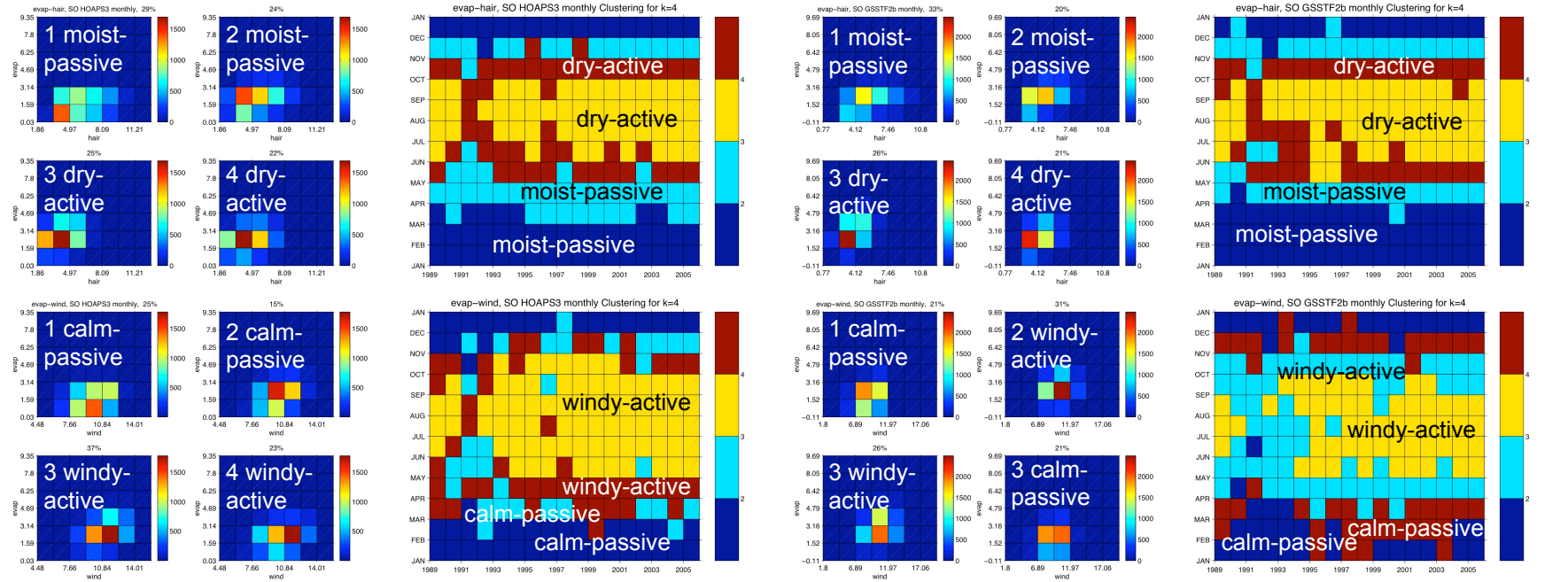
Cluster Analysis Results



GSSTF2b has 4 seasonal modes, winter and summer do not show expected relationship between evap and SST

HOAPS3 has only 2 modes, neither shows expected relationship between evap and SST

SST is not directly driving evaporation *in this region*



What We've Learned So Far

- There are differences between GSSTF2b and HOAPS3 which are apparent from climatologies, but do not, in general, affect clusters.

What We've Learned So Far

- There are differences between GSSTF2b and HOAPS3 which are apparent from climatologies, but do not, in general, affect clusters.
- GSSTF2b and HOAPS3 clusters are similar – generally two regimes, one for summer and one for winter, with possibly a transitional mode.

What We've Learned So Far

- There are differences between GSSTF2b and HOAPS3 which are apparent from climatologies, but do not, in general, affect clusters.
- GSSTF2b and HOAPS3 clusters are similar – generally two regimes, one for summer and one for winter, with possibly a transitional mode.
- Exception is SST (which is not from SSM/I), where GSSTF2b and HOAPS3 exhibit different behavior

What We've Learned So Far

- There are differences between GSSTF2b and HOAPS3 which are apparent from climatologies, but do not, in general, affect clusters.
- GSSTF2b and HOAPS3 clusters are similar – generally two regimes, one for summer and one for winter, with possibly a transitional mode.
- Exception is SST (which is not from SSM/I), where GSSTF2b and HOAPS3 exhibit different behavior
- Evap-wind and evap-air humidity regimes display expected relationship, but evap-SST does not, some or all of the time (depending on dataset) – suggests SST is not directly controlling evaporation (possibly indirectly via influence on air humidity?)

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.

- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.
- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.
- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.
- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.
- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.
- Would like to validate fluxes with ship/buoy/station data where possible.

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.
- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.
- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.
- Would like to validate fluxes with ship/buoy/station data where possible.
- Cluster method found largest mode of variability, the annual cycle. To find other modes, could try various options –

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.
- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.
- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.
- Would like to validate fluxes with ship/buoy/station data where possible.
- Cluster method found largest mode of variability, the annual cycle. To find other modes, could try various options –
    - Remove annual cycle? Zonal means?

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.

- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.

- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.

- Would like to validate fluxes with ship/buoy/station data where possible.

- Cluster method found largest mode of variability, the annual cycle. To find other modes, could try various options –
    - Remove annual cycle? Zonal means?
    - Analyze each season separately?

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.

- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.

- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.

- Would like to validate fluxes with ship/buoy/station data where possible.

- Cluster method found largest mode of variability, the annual cycle. To find other modes, could try various options –
    - Remove annual cycle? Zonal means?
    - Analyze each season separately?
    - Composite by SAM phase?

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.

- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.

- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.

- Would like to validate fluxes with ship/buoy/station data where possible.

- Cluster method found largest mode of variability, the annual cycle. To find other modes, could try various options –
    - Remove annual cycle? Zonal means?
    - Analyze each season separately?
    - Composite by SAM phase?
    - Change limits of 2d histograms to focus on different parts of parameter space?

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.

- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.

- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.

- Would like to validate fluxes with ship/buoy/station data where possible.

- Cluster method found largest mode of variability, the annual cycle. To find other modes, could try various options –
    - Remove annual cycle? Zonal means?
    - Analyze each season separately?
    - Composite by SAM phase?
    - Change limits of 2d histograms to focus on different parts of parameter space?
    - What is optimum time resolution for analysis? Monthly vs. daily.

Data wish list and thoughts for the future

- Smaller resolution data – cannot see fine scale features.

- Flux data near coasts/ice edge – would be great if we could see polynas, coastal upwelling, the effect of cold air outbreaks, etc – we only have data for the open ocean. Near shore/ice behavior could be very different.

- Incomplete representation of fluxes when there are thick clouds and rain – not sampling entire flux/component phase space.

- Would like to validate fluxes with ship/buoy/station data where possible.

- Cluster method found largest mode of variability, the annual cycle. To find other modes, could try various options –
    - Remove annual cycle? Zonal means?
    - Analyze each season separately?
    - Composite by SAM phase?
    - Change limits of 2d histograms to focus on different parts of parameter space?
    - What is optimum time resolution for analysis? Monthly vs. daily.
    - Another method entirely?


Thank you!
Photo:
Commonwealth of
Australia
© 2007 Wayne Papps