Climate Data Records: A MODIS Perspective

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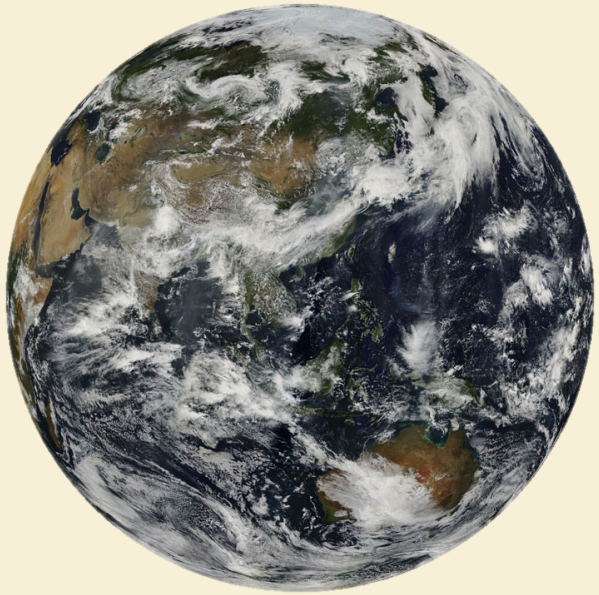
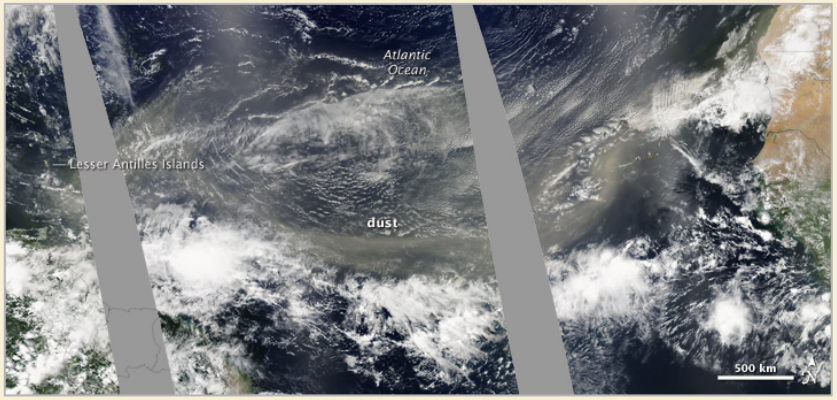
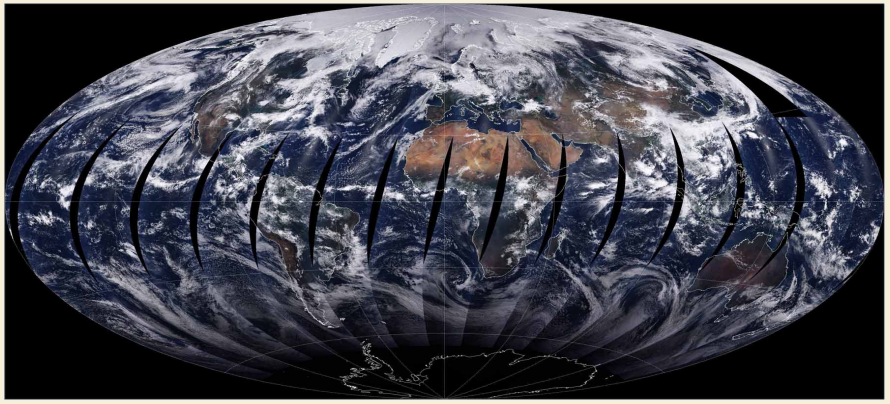
Workshop on *Observations & Modeling of Aerosol/Cloud Properties for Climate Studies*

Paris, 12-14 Sept 2011

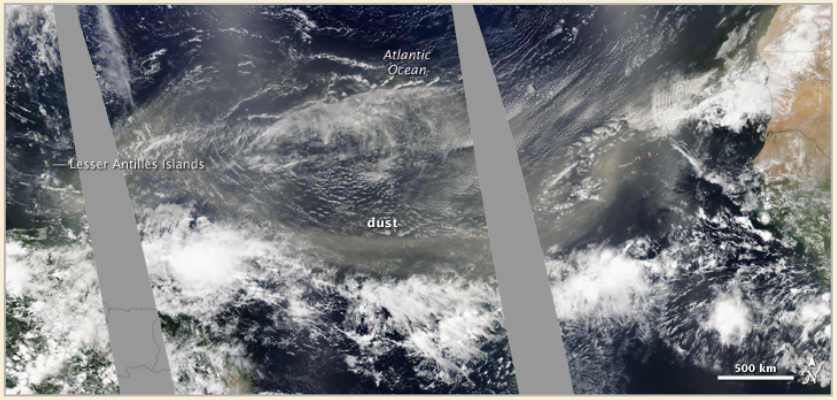


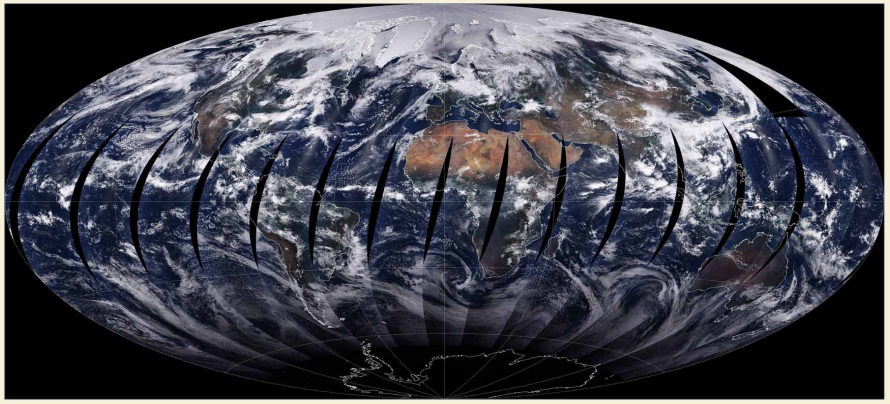




Outline:

- Global Analyses
  - Trends
  - ENSO Correlations
- Some Lessons-Learned





Outline:

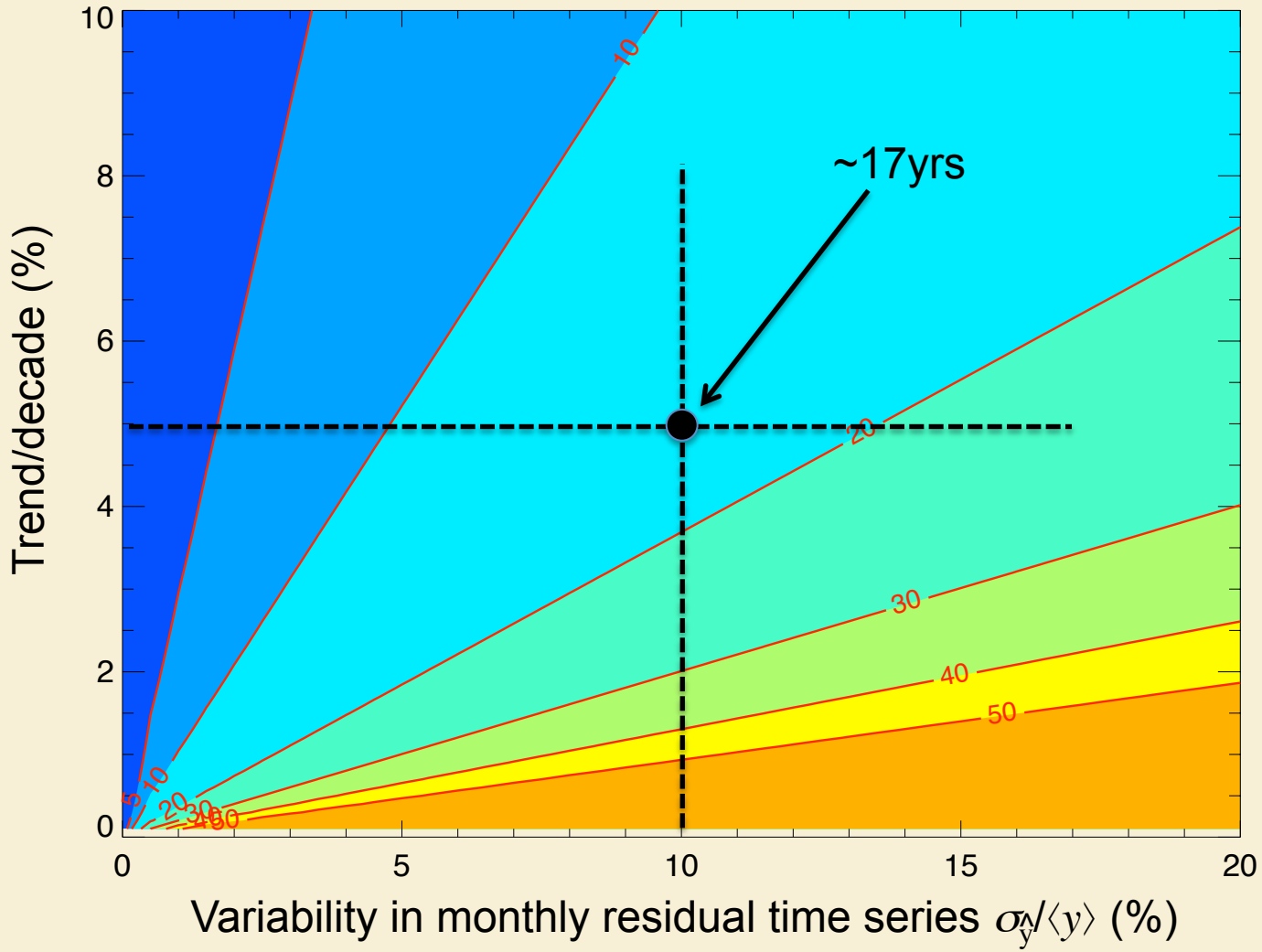
- Global Analyses
  - Trends
    - Time-to-Detection vs. grid size
    - Example trends, instrument artifacts
  - ENSO Correlations
- Some Lessons-Learned

Motivation

- Trends
  - For observed MODIS temporal variability on regional scales, what is the expected “time to detection” for a given trend?
  - Consistency between Terra and Aqua MODIS? Lack of consistency traced to instrument differences? Statistically significant regional trends found?
- Sensitivity of retrievals to interannual (low frequency) climate variability, e.g., ENSO
  - Correlation of atmosphere properties to ENSO useful for climate model evaluation (e.g., GFDL AM3 cloud fields)
  - To what extent can ENSO responses alias into trend observations?
- Datasets and Analysis
  - Monthly mean anomalies derived from archived MODIS Atmosphere Team Terra and Aqua monthly Level-3 aggregations
  - Analyses for various equal-angle grids, from 1° (native Level-3 resolution) to regional and zonal
  - All analysis includes effects of data set temporal correlations (“order 1” autocorrelation for trend calculations)

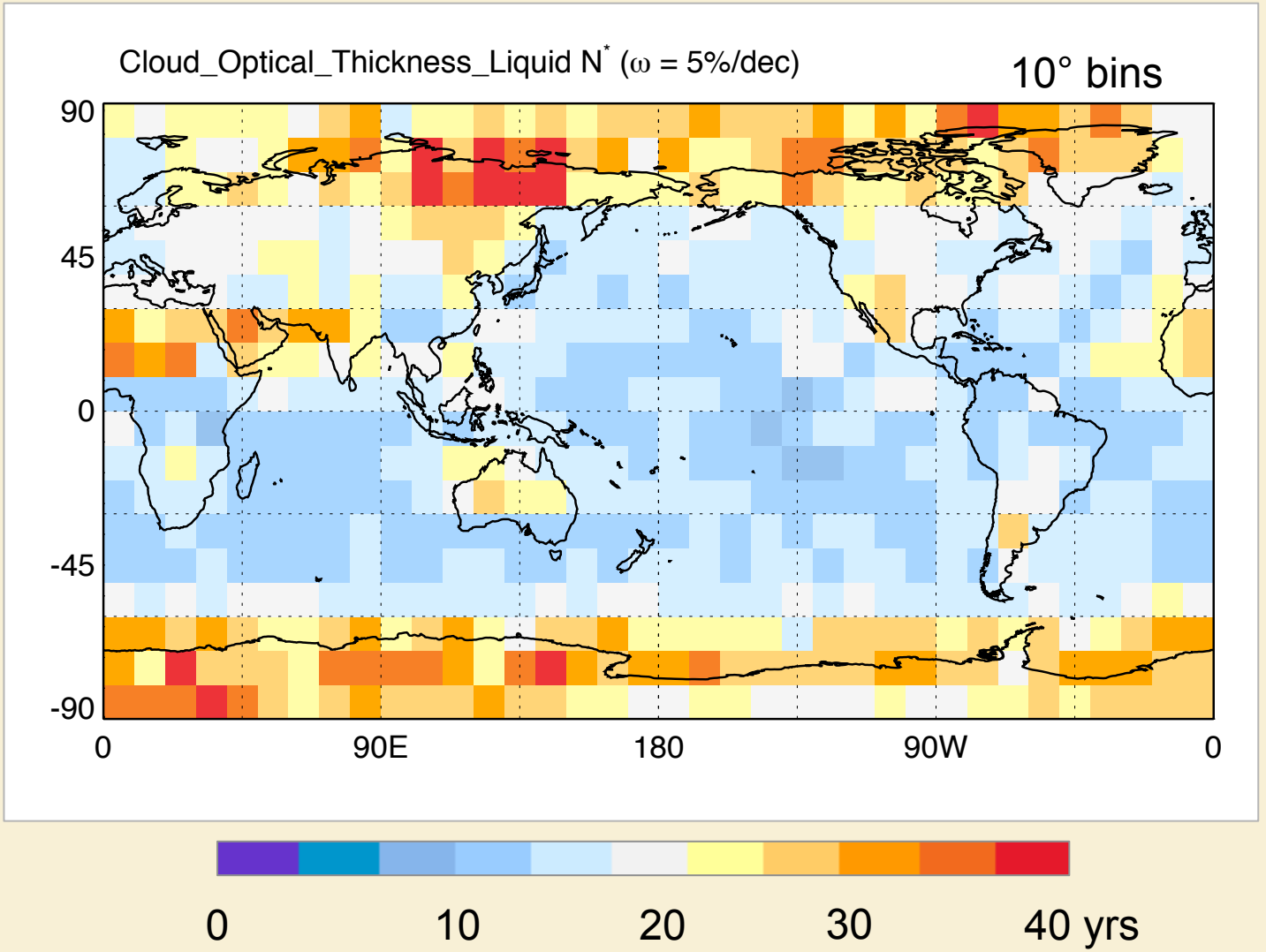
Number of Years Required to Detect a Trend

(90% prob. of detecting a trend to a 0.05 statistical level, no autocorrelation: Tiao et al., 1990; Weatherhead et al., 1998)



Time Required for Detection of 5%/decade Trend

(90% prob. of detecting a 0.05 statistical significance,
from 10 yr monthly anomaly variability w/autocorrelation correction)



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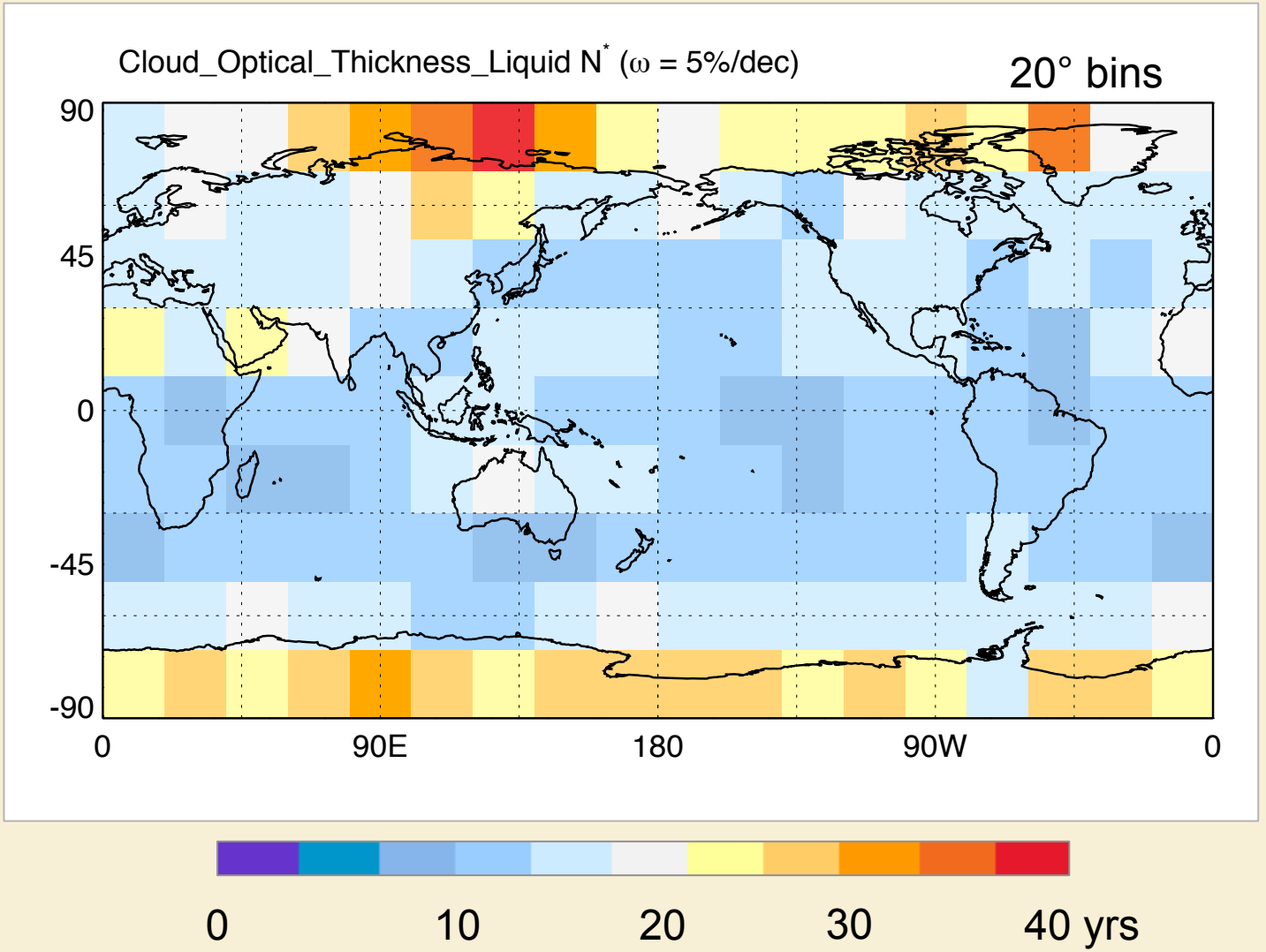

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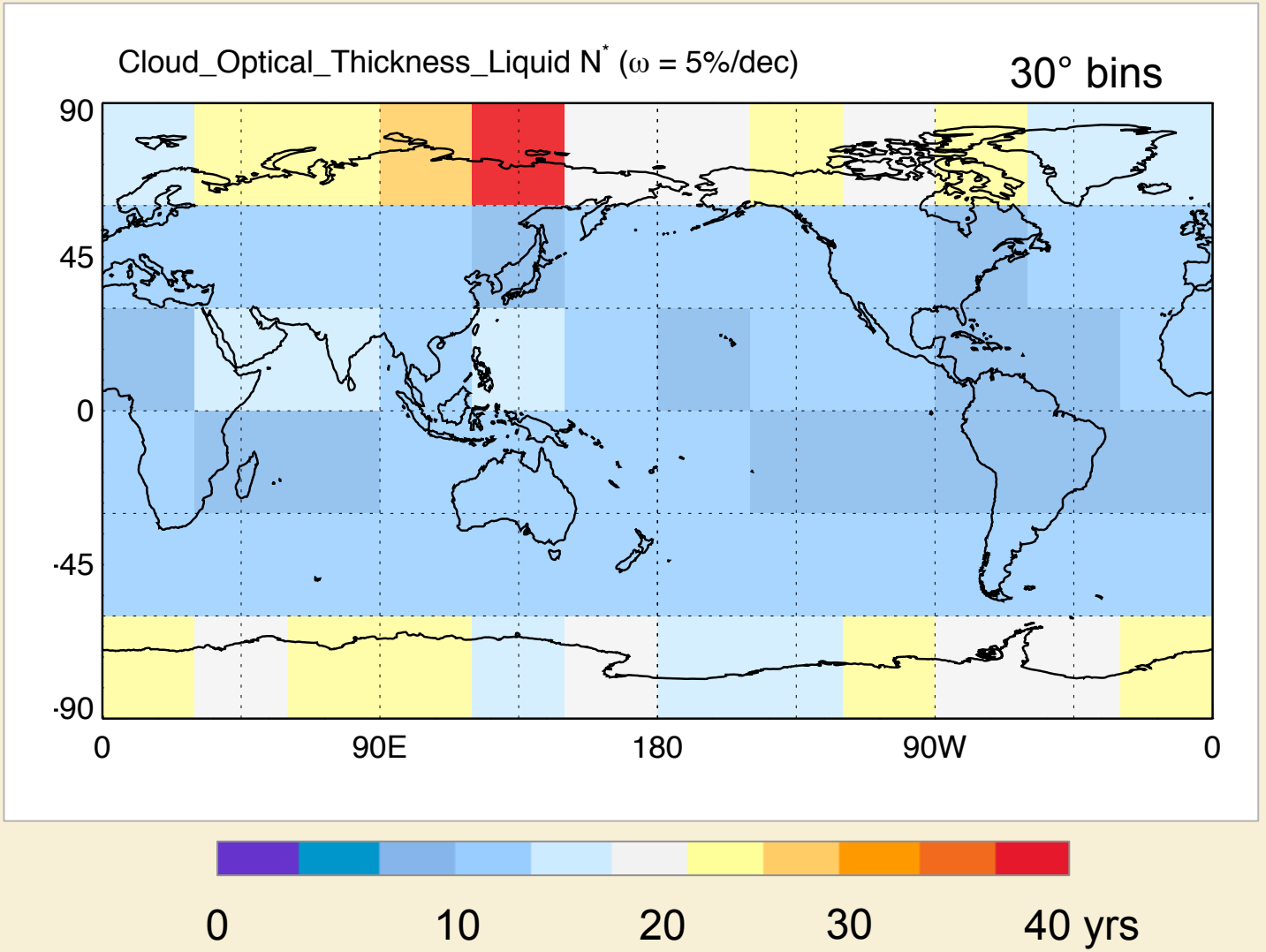

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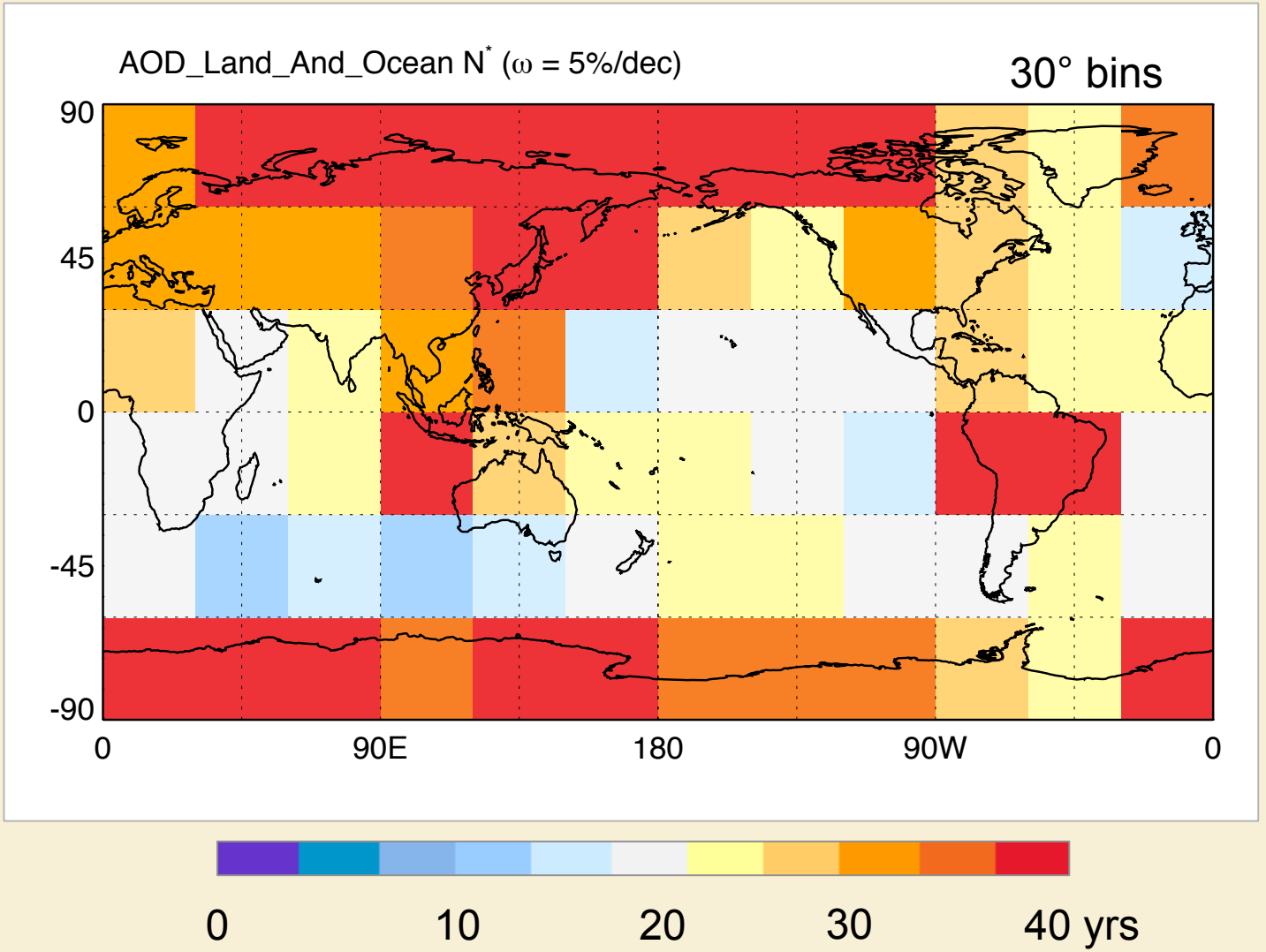

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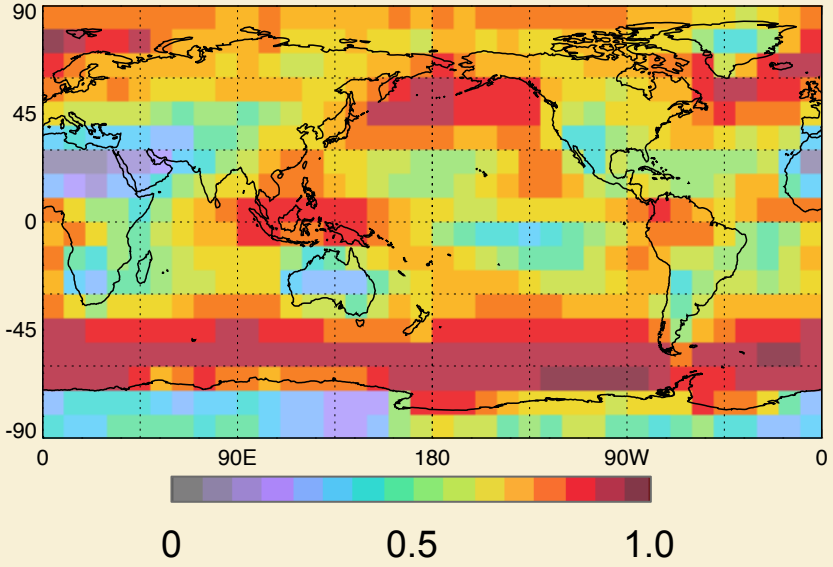
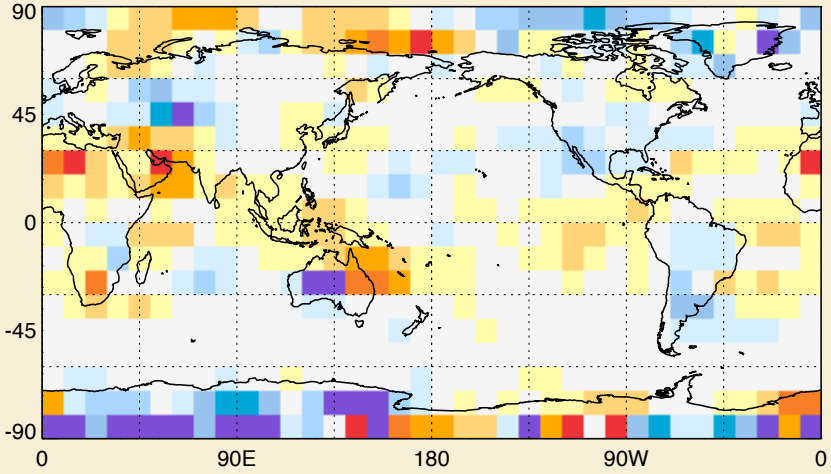
Annual Mean Fraction (July 2000 – June 2001)



Cloud Fraction from MODIS mask, Terra (10° binning, daytime observations only)

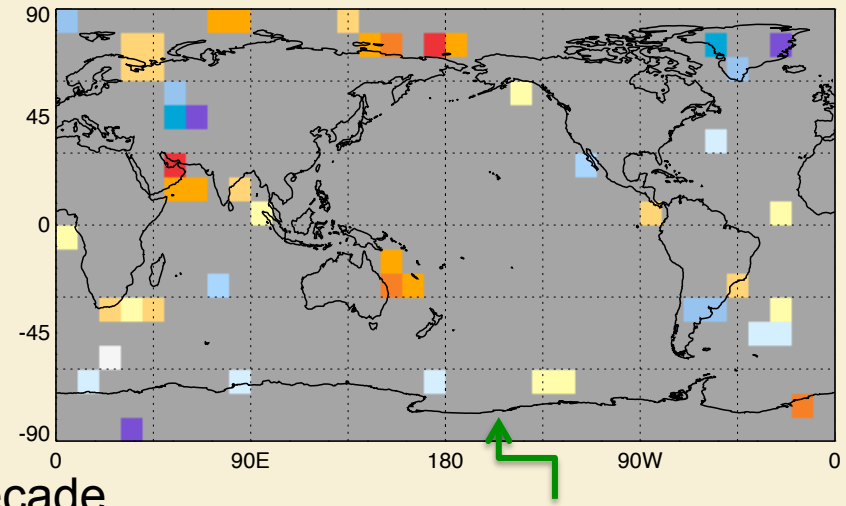
Cloud Fraction Trends

(monthly anomalies, July 2000 – June 2010)

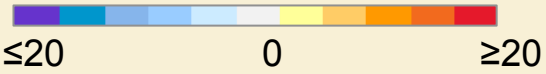


Trends Masked by Significance Level ≤ 0.05

(w/autocorrelation correction in *t*-test)



%/decade



~8% of grid boxes

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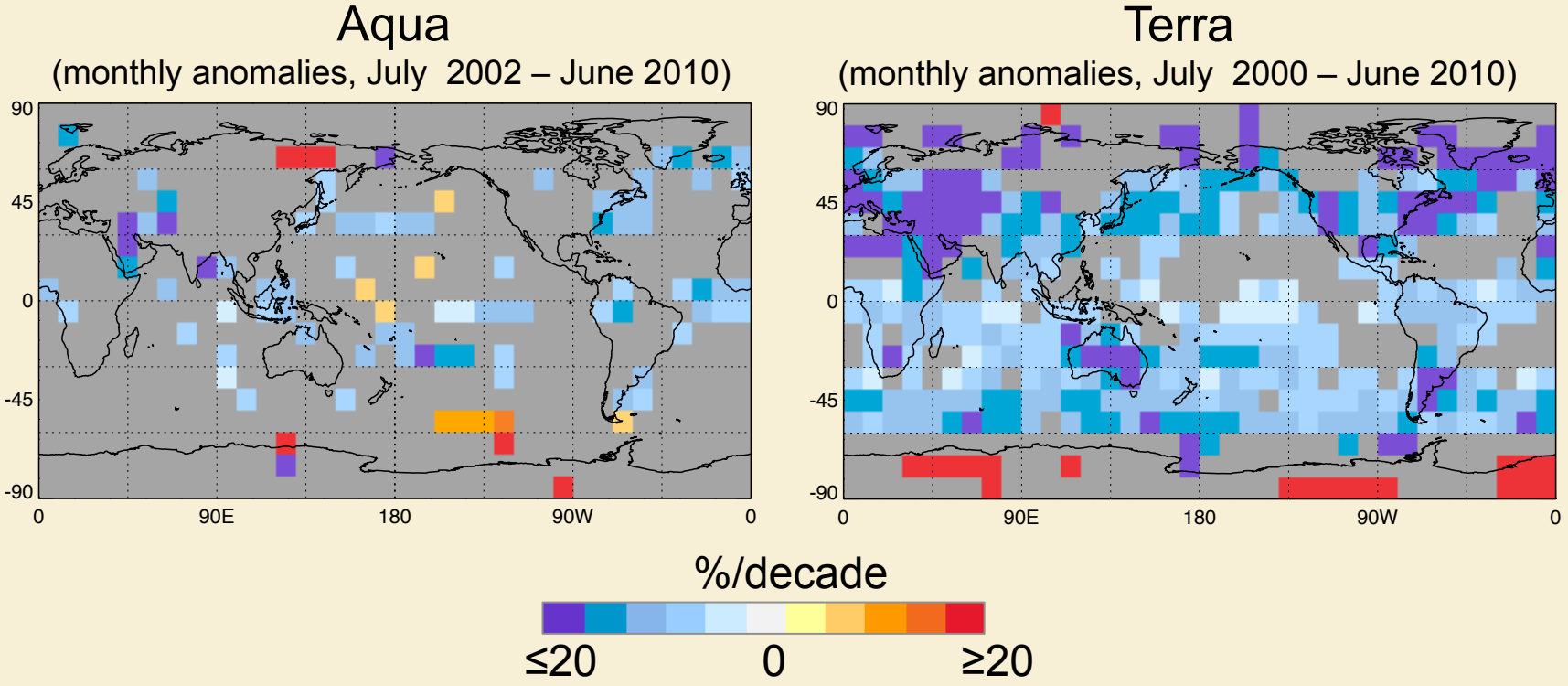
MODIS Cloud Optical Thickness Trends, Aqua vs. Terra (water clouds, 10° binning)



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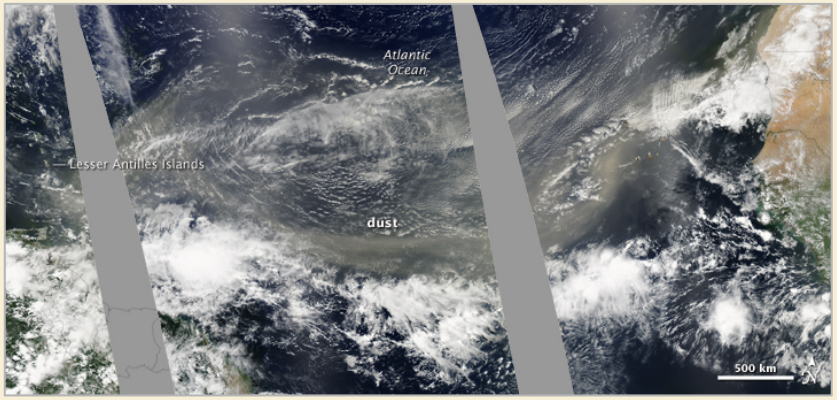

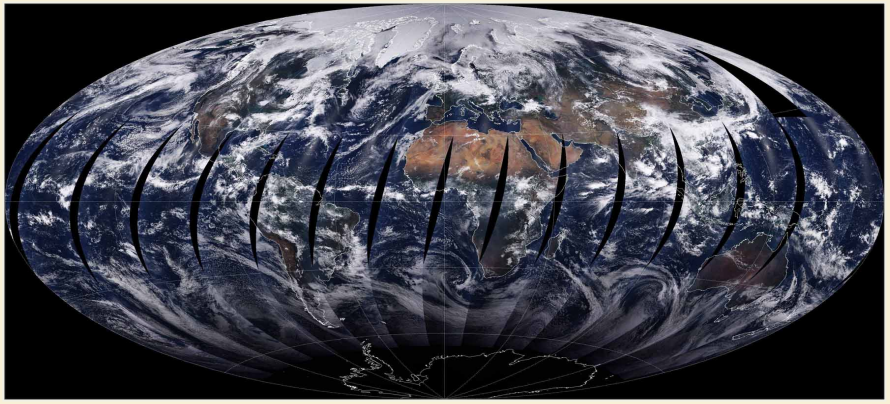

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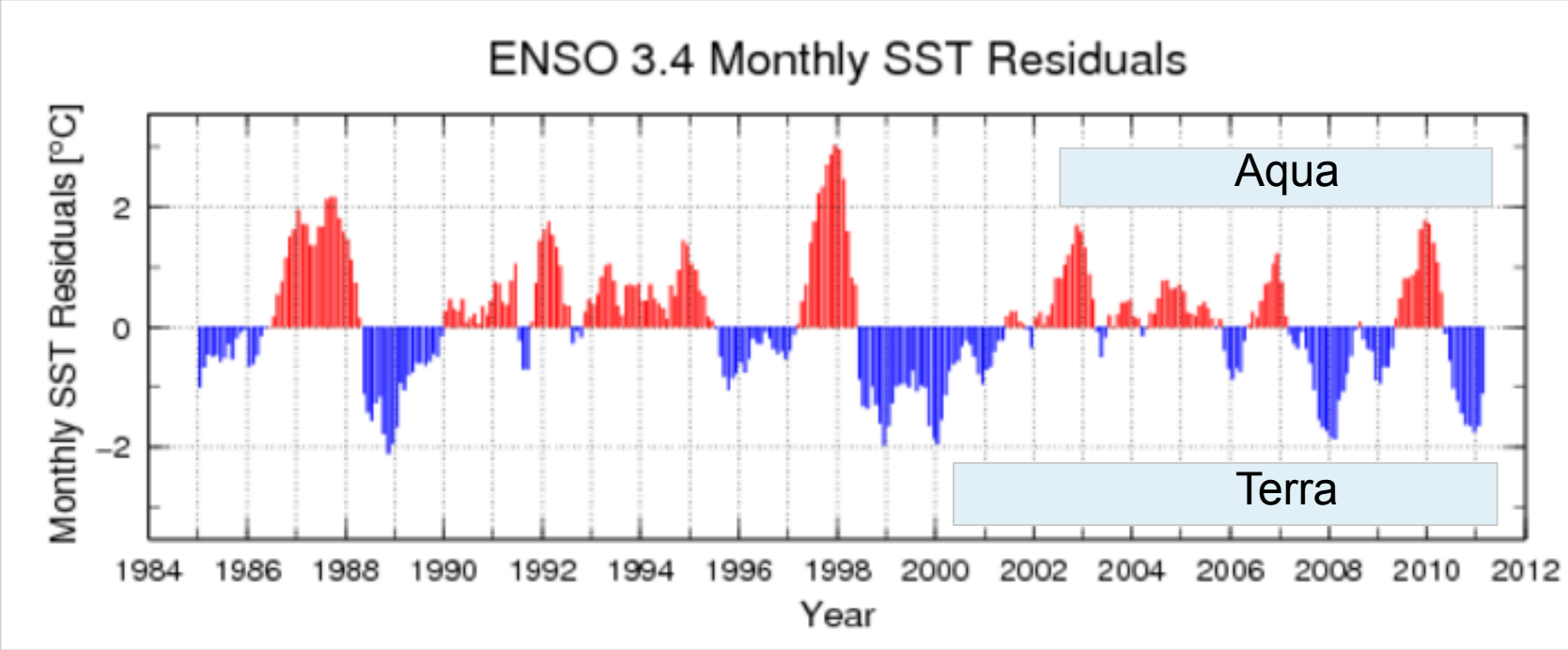
  - ▼ ENSO Correlations
    - ▶ Aliasing into trends?
- ▶ Some Lessons-Learned

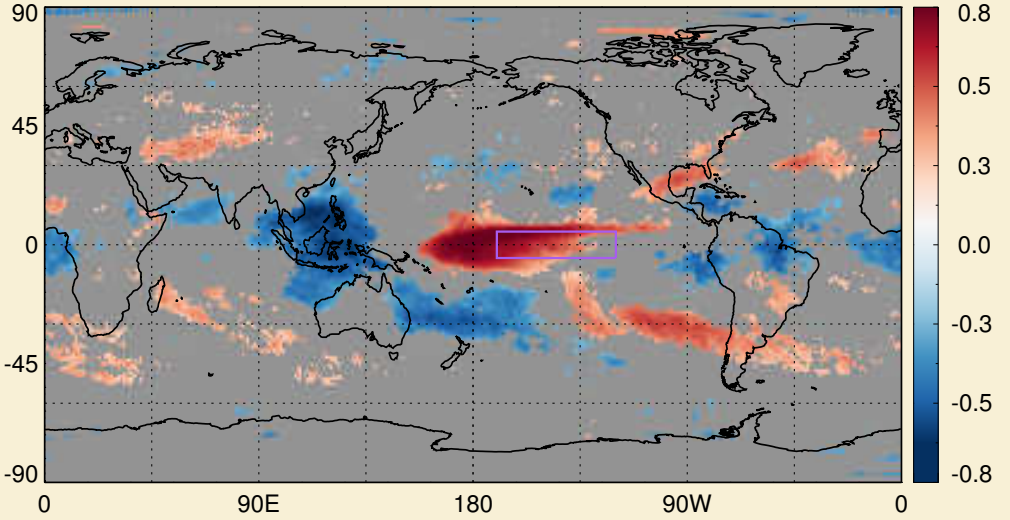
ENSO3.4 SST Anomaly Index

(avg. temperature in a box in east-central equatorial Pacific)

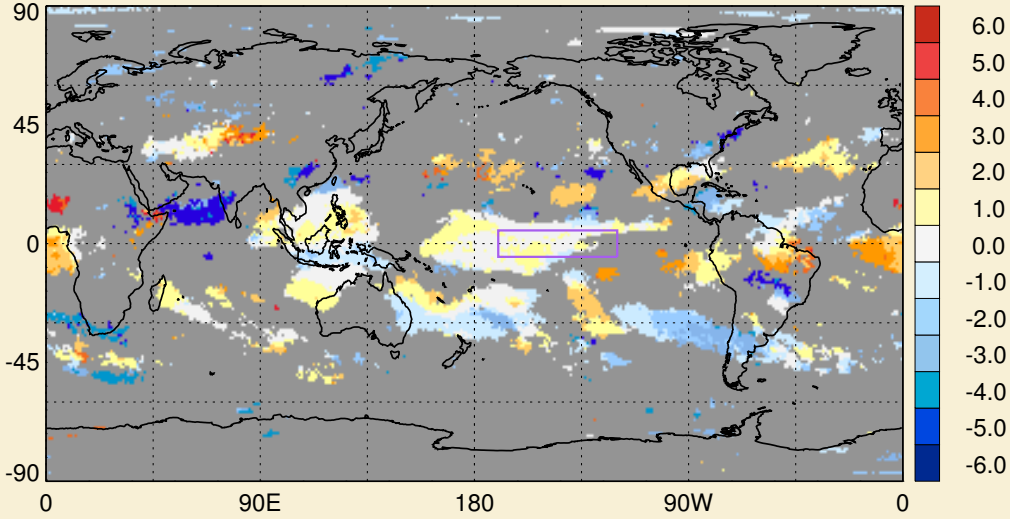


Example ENSO3.4 vs. MODIS Monthly Anomaly Correlation
1° bins, masked by 1% statistical sig., July 2002–Jan 2011

High Cloud Amount Correlation



High Cloud Amount



Lag (months)
Modified *Chen et al.*, 2007

[red => cloud response lags E3.4 index; blue => cloud response precedes index]

Example ENSO3.4 vs. MODIS Monthly Anomaly Correlation
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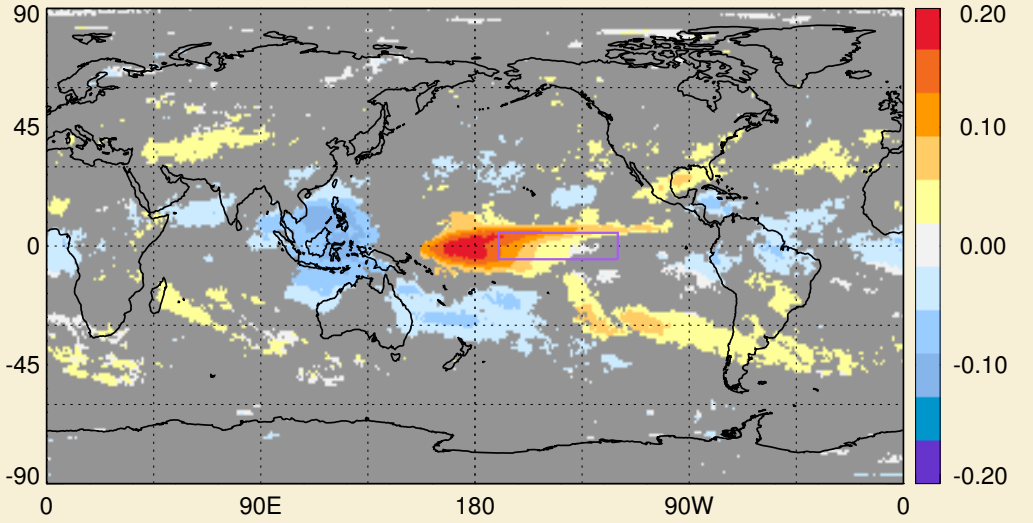
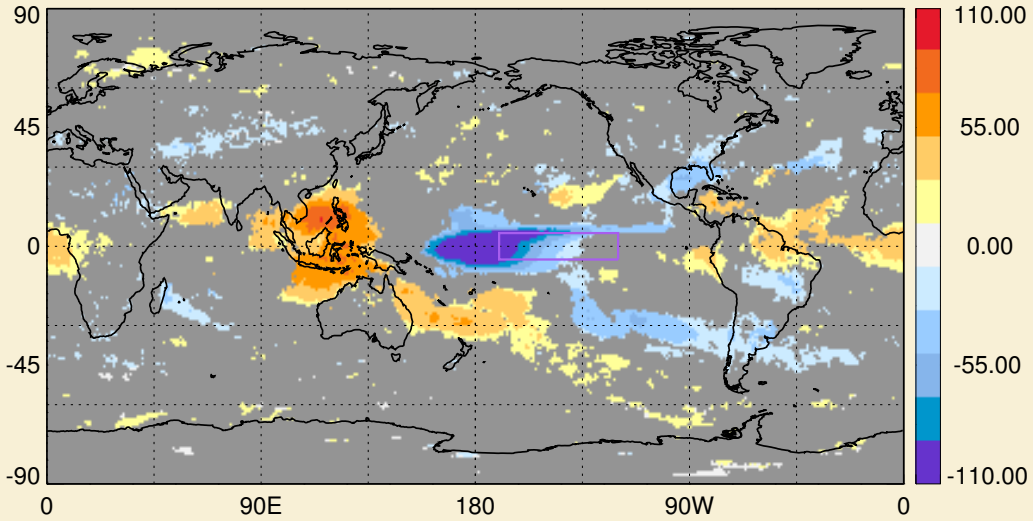
High Cloud Amount and Pressure: Derived Regression Slopes



High Cloud Amount
df_c/dT (K^{-1})



Cloud-top Pressure
dp_c/dT (hPa-K^{-1})

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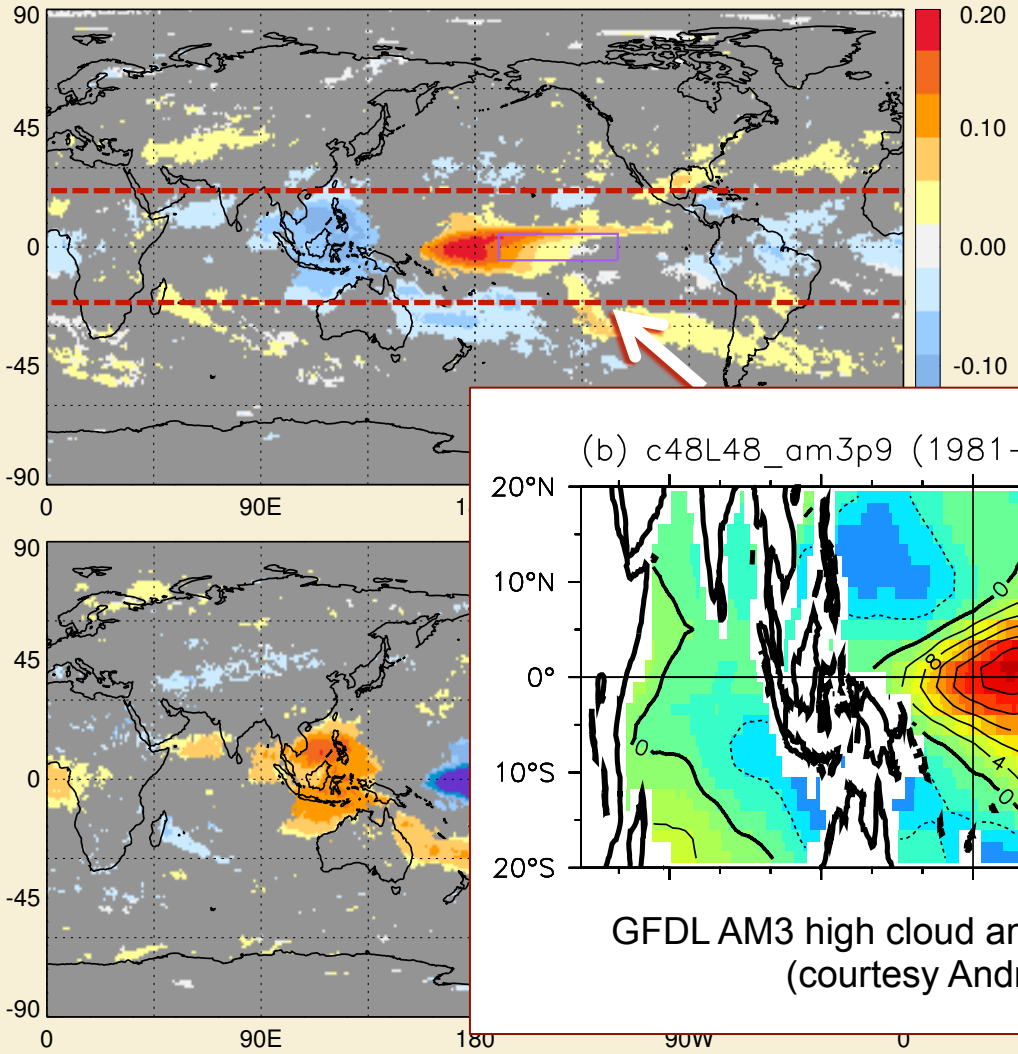
1° bins, masked by 1% statistical sig., July 2002–Jan 2011

High Cloud Amount and Pressure: Derived Regression Slopes



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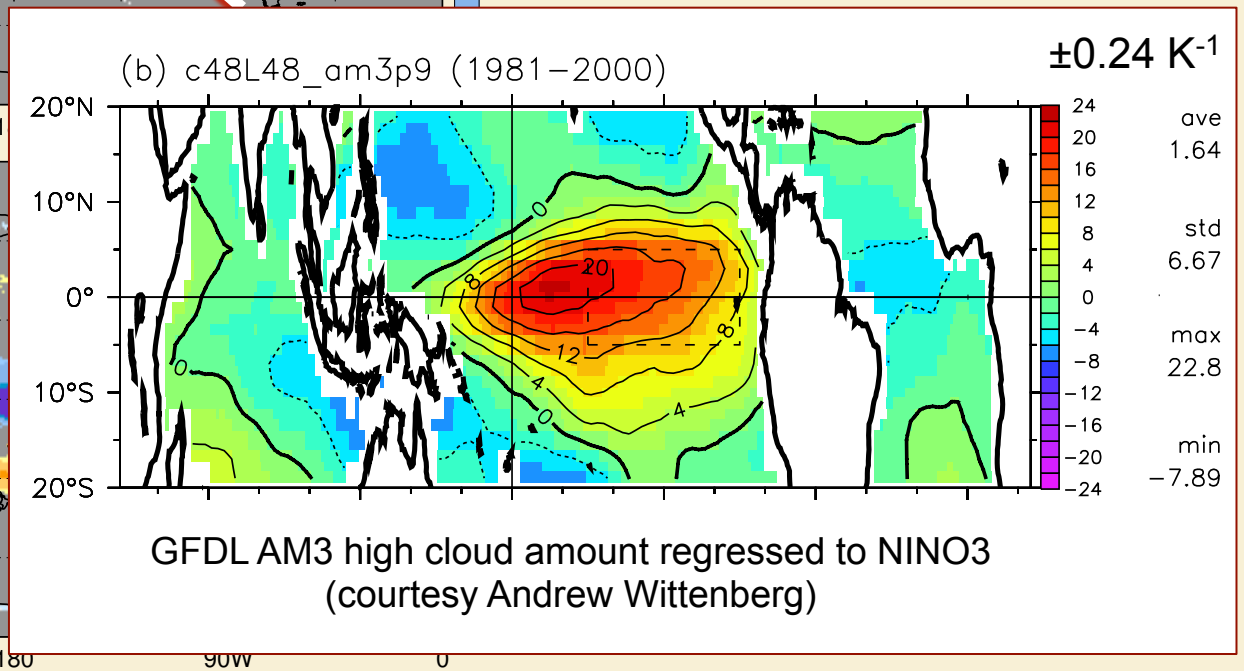
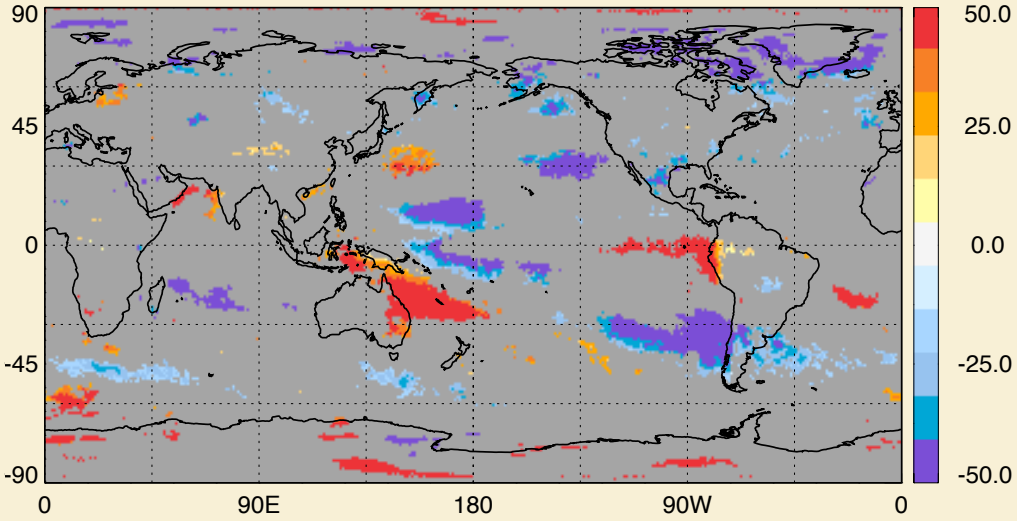


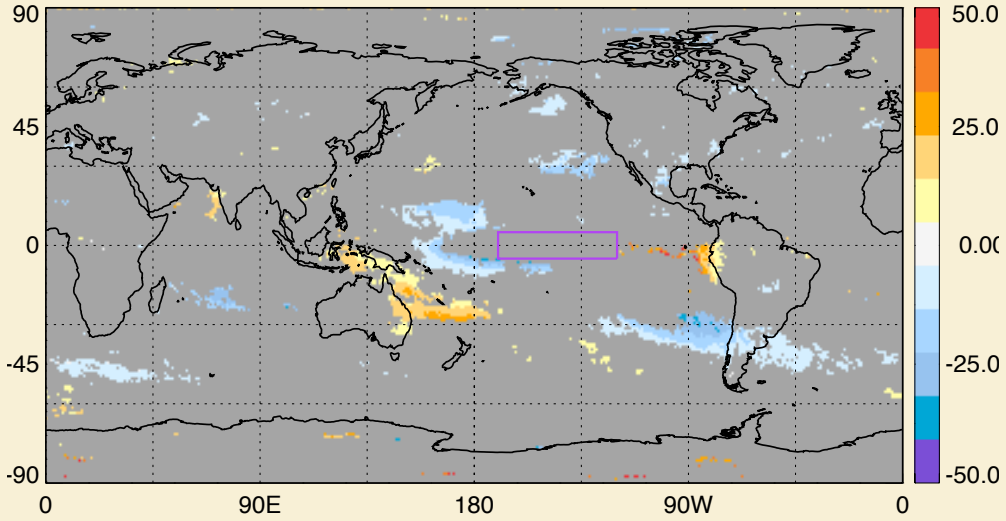
GFDL AM3 high cloud amount regressed to NINO3
(courtesy Andrew Wittenberg)

Example ENSO3.4 Component of MODIS Trend (from Monthly Anomalies)
Aqua, 1° bins, July 2002–Jun 2010

High Cloud Amount



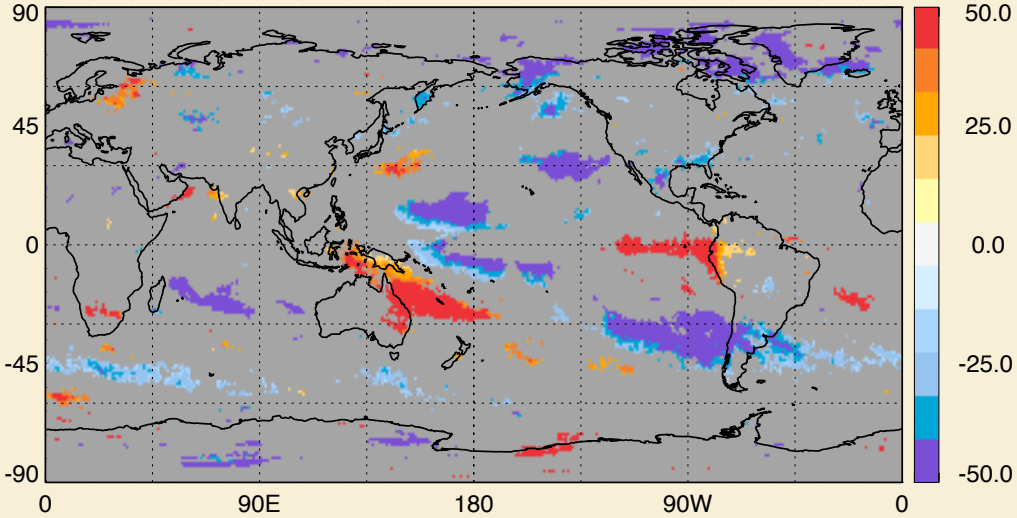
MODIS Aqua Trend (%/dec)
July 2002–Jun 2010
(masked by stat. sig. <0.05)



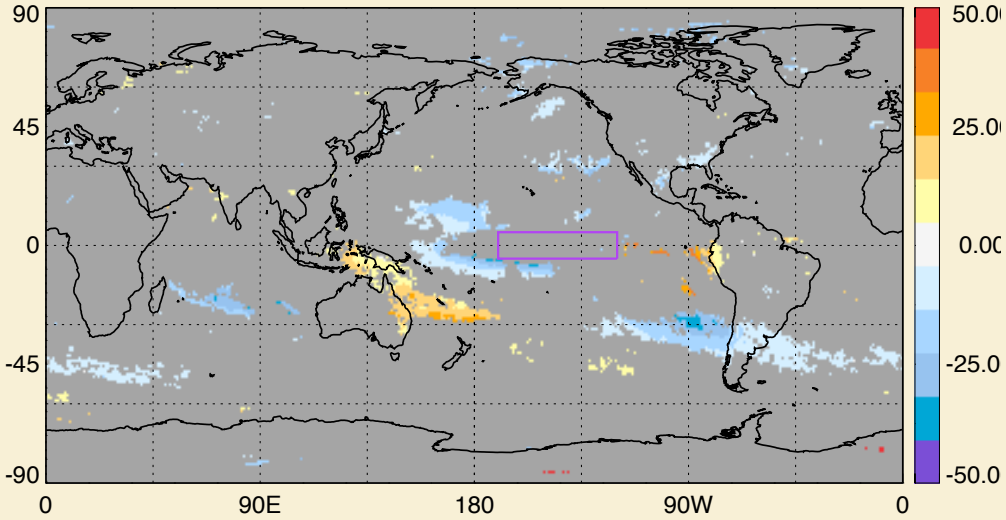
ENSO component of trend
derived from correlation
regression slope
(masked by trend & ENSO3.4
correlation sig. < 0.05)

Example ENSO3.4 Component of MODIS Trend (from Monthly Anomalies)
Terra, 1° bins, July 2002–Jun 2010

High Cloud Amount



MODIS Terra Trend (%/dec)
July 2002–Jun 2010
(masked by stat. sig. <0.05)



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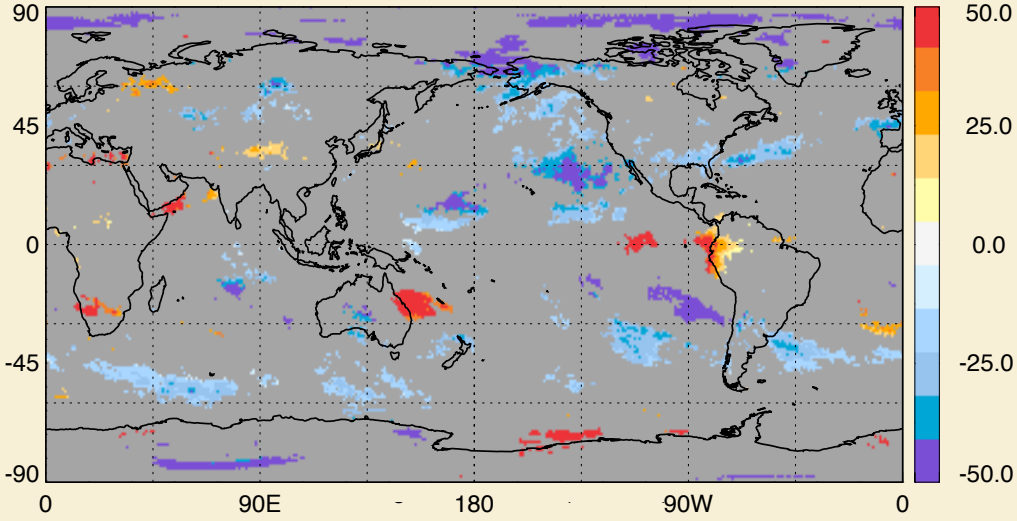

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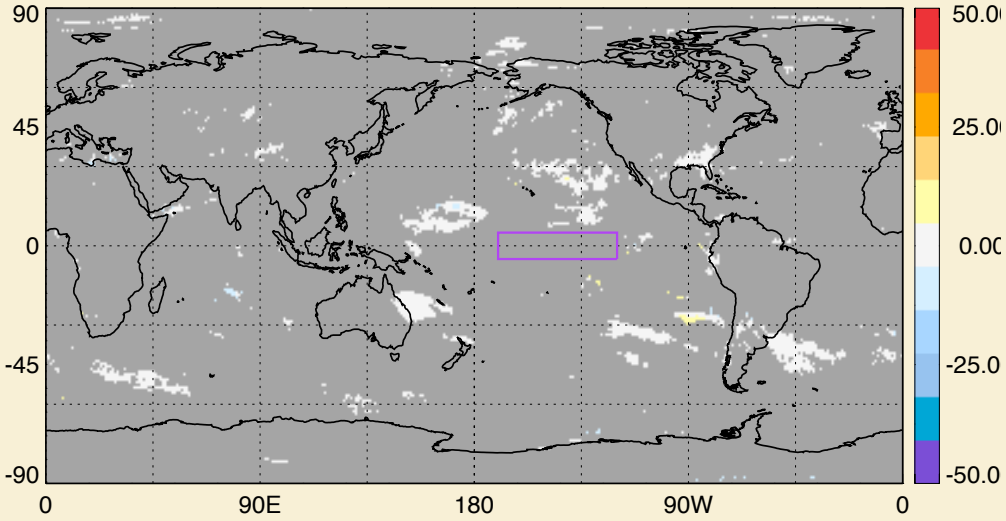

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derived from correlation
regression slope
(masked by trend & ENSO3.4
correlation sig. < 0.05)

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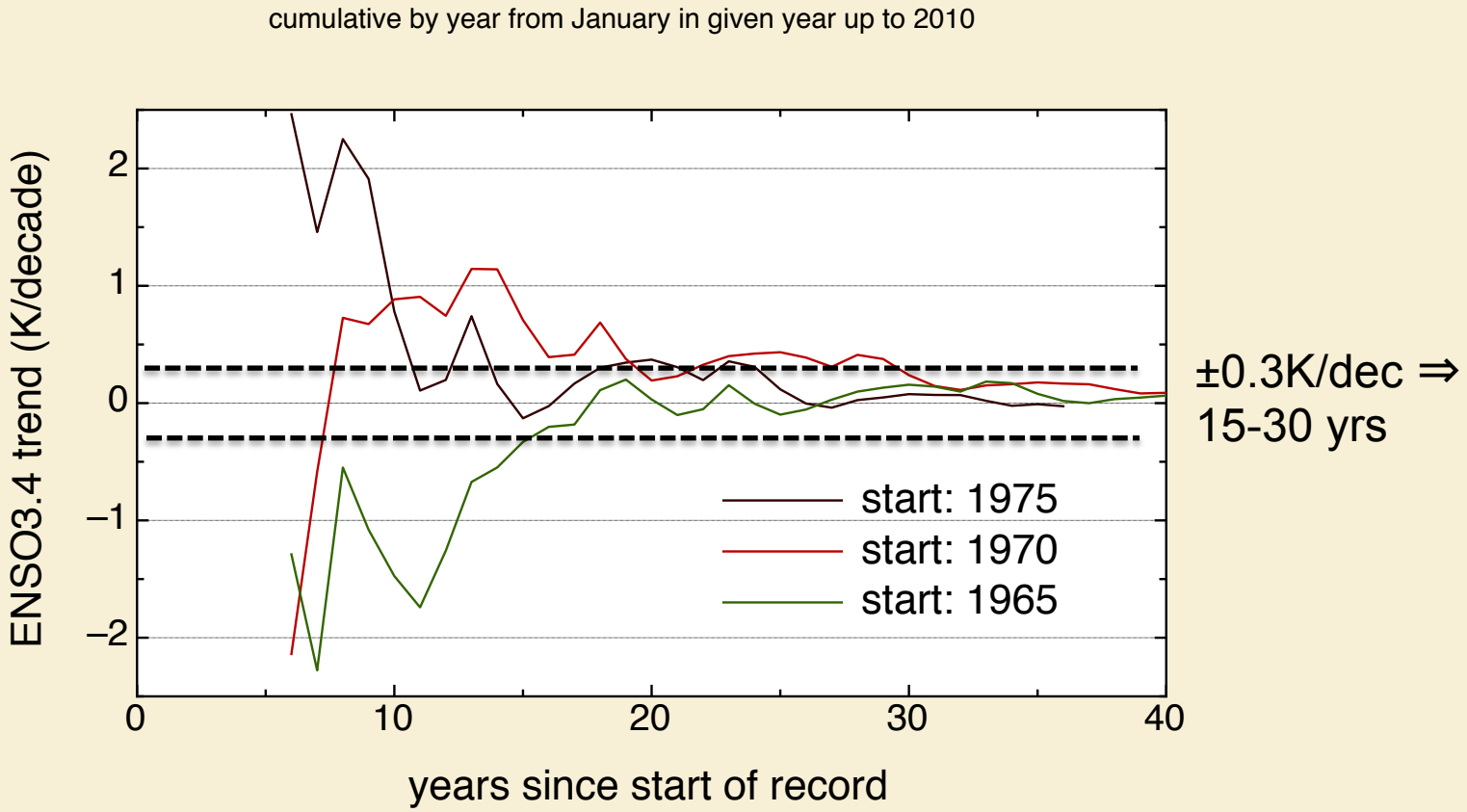
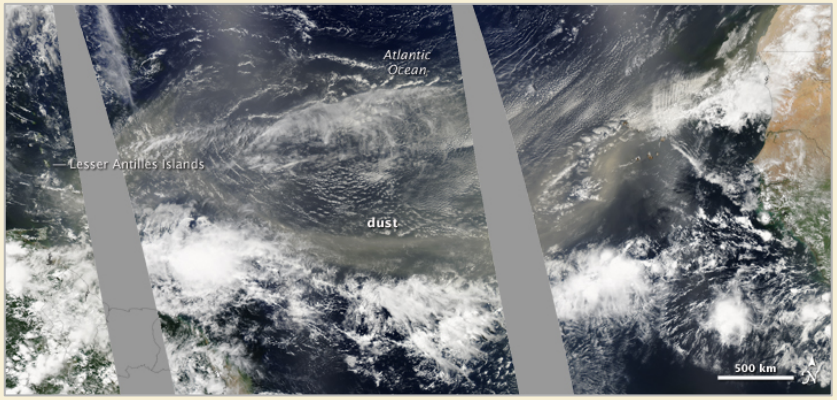
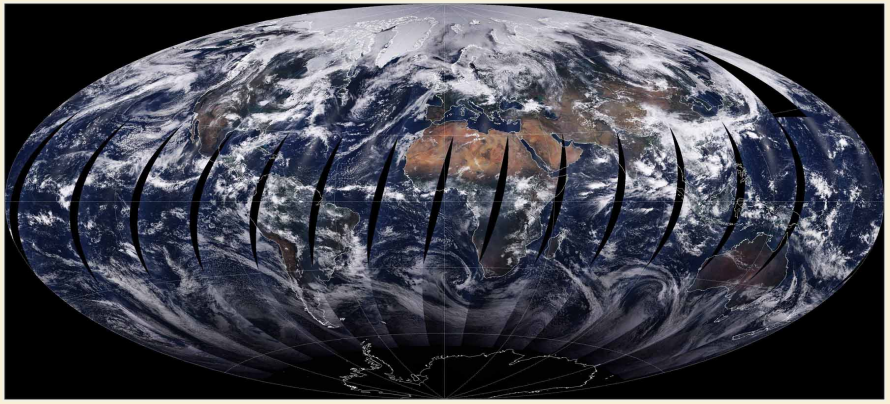
ENSO3.4 Aliasing Into Trends

Number of years for ENSO trend to decay to less than some value?







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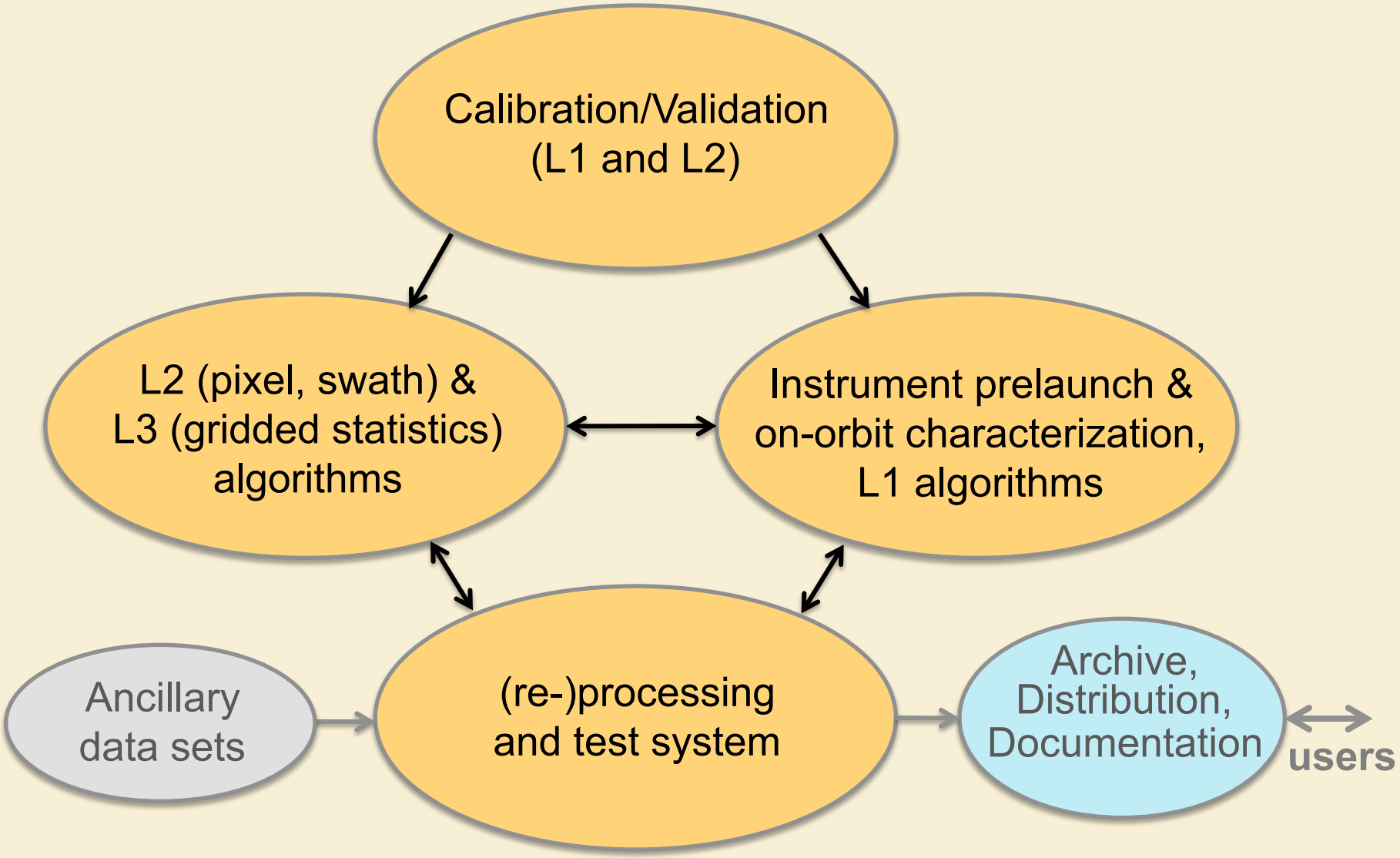
Platnick et al., CDR, 2 Aug 2011

A Coordinated System/Infrastructure of Elements is Required for Production and Sustainability of Climate Records



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Thank you!