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Recent dust variability over South Asia controlled by North Atlantic SST anomalies

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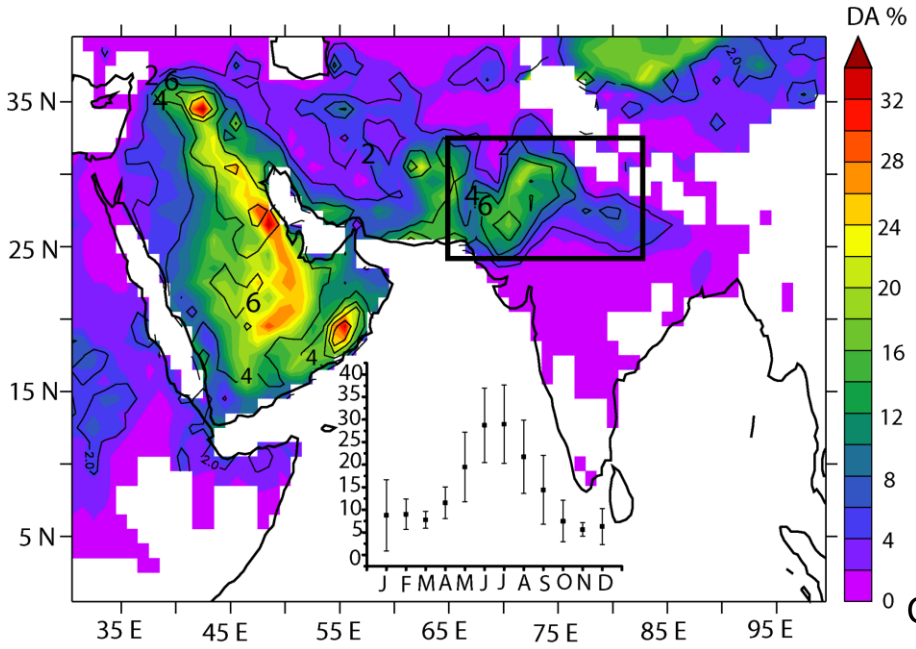
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Objective: To examine how changes in the spatial pattern of ocean warming during 2001-2018 have impacted large-scale circulation that controls South Asian dust.

Distribution of percentage frequency of days with high dust activity ($DA_{\%}$) for 2001-2018



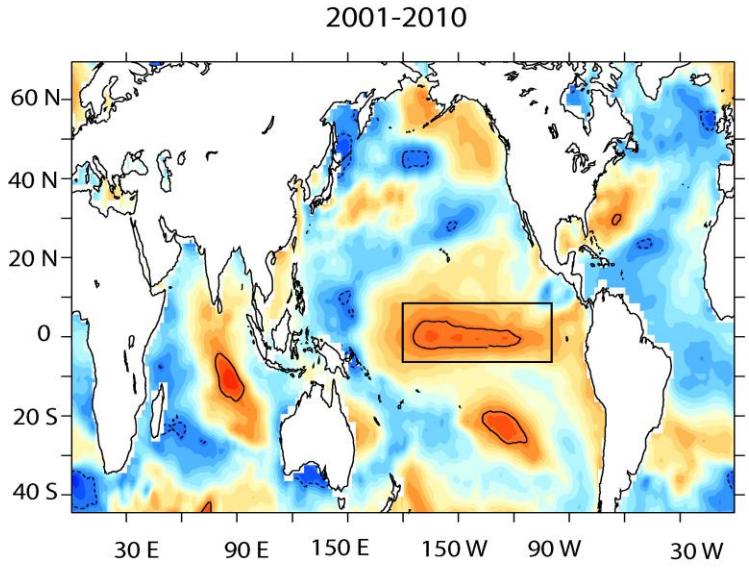
- Data: MODIS deep-blue aerosol data aboard Terra (2001-2018) and Aqua (2003-2018). Level 3, version 6.1.
- $DA_{\%}$ is defined as the percentage of days in a year when AOD > 0.6 and Angstrom exponent < 0.2.
- $DA_{\%}$ trend has been validated against Metop-A dust optical depth and MISR non-spherical AOD.
- South Asia domain: 65-82 E; 24-32 N.

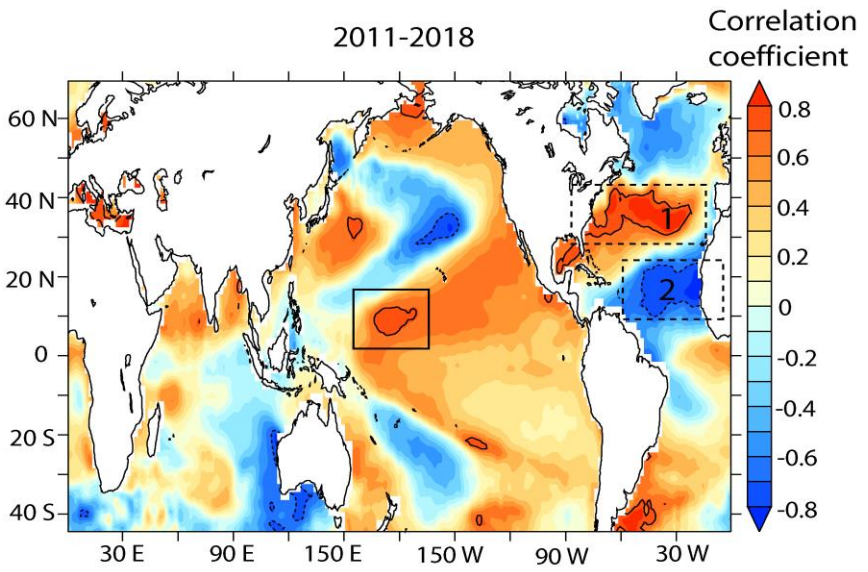
Contours: standard deviation of $DA_{\%}$

Other data:

- Meteorological fields from NCEP/NCAR Reanalysis.
- Average of SST from 3 products: ERSST v5, COBE SST v2 and OISST v2.

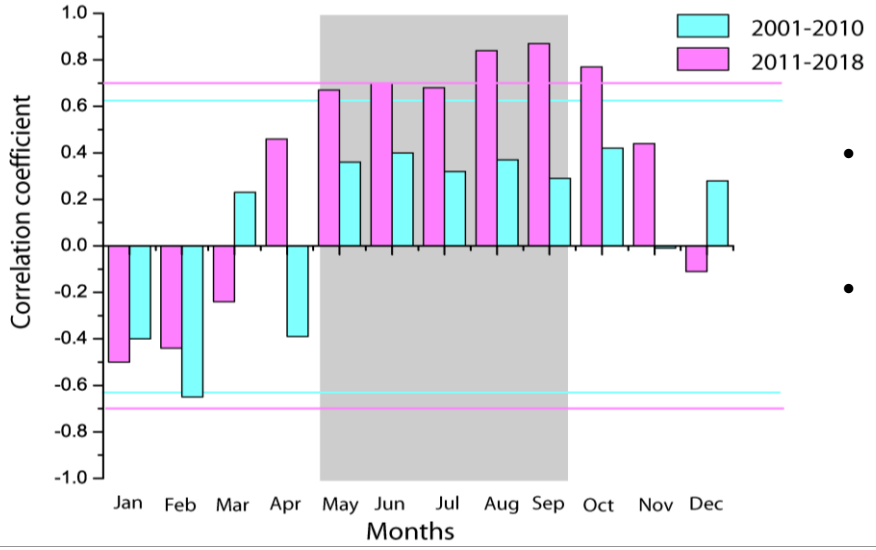
Changing pattern of correlation between $DA_{\%}$ over South Asia and SST





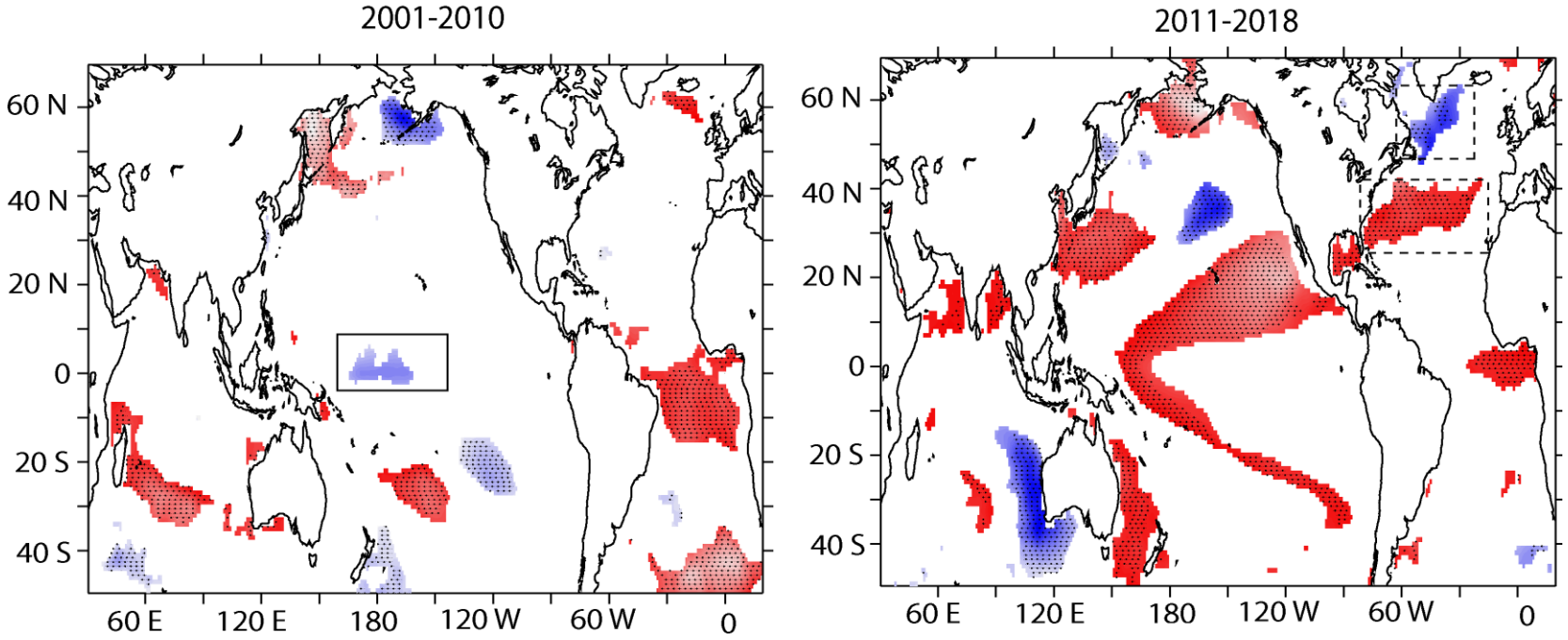
North Atlantic Difference Index **(NADI):**
April-June SST in Region 1 minus Region 2

Correlation between NADI and monthly $DA_{\%}$

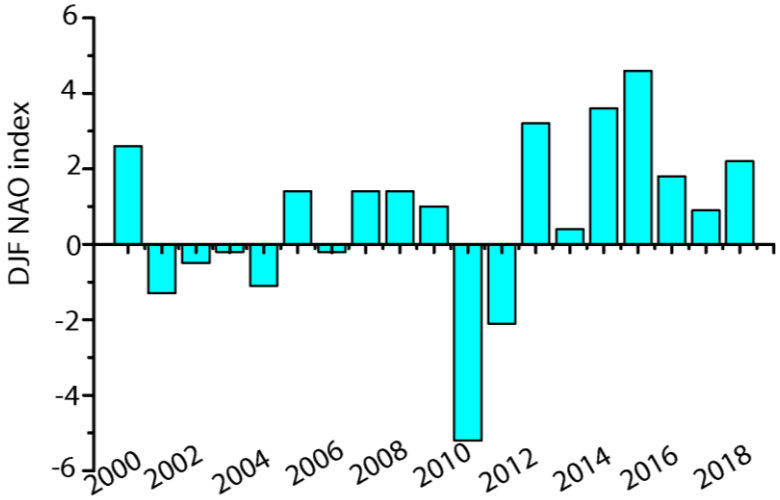


- During 2001-2010, $DA_{\%}$ has significant positive correlation with SST over central Pacific Nino region.
- Correlation between NADI and $DA_{\%}$ is stronger and significant (p-value<0.05) for 2011-2018, during May-October, in comparison to 2001-2010.

Trend of sea surface temperature



Red: positive slope; Blue: negative slope (p-value < 0.05)

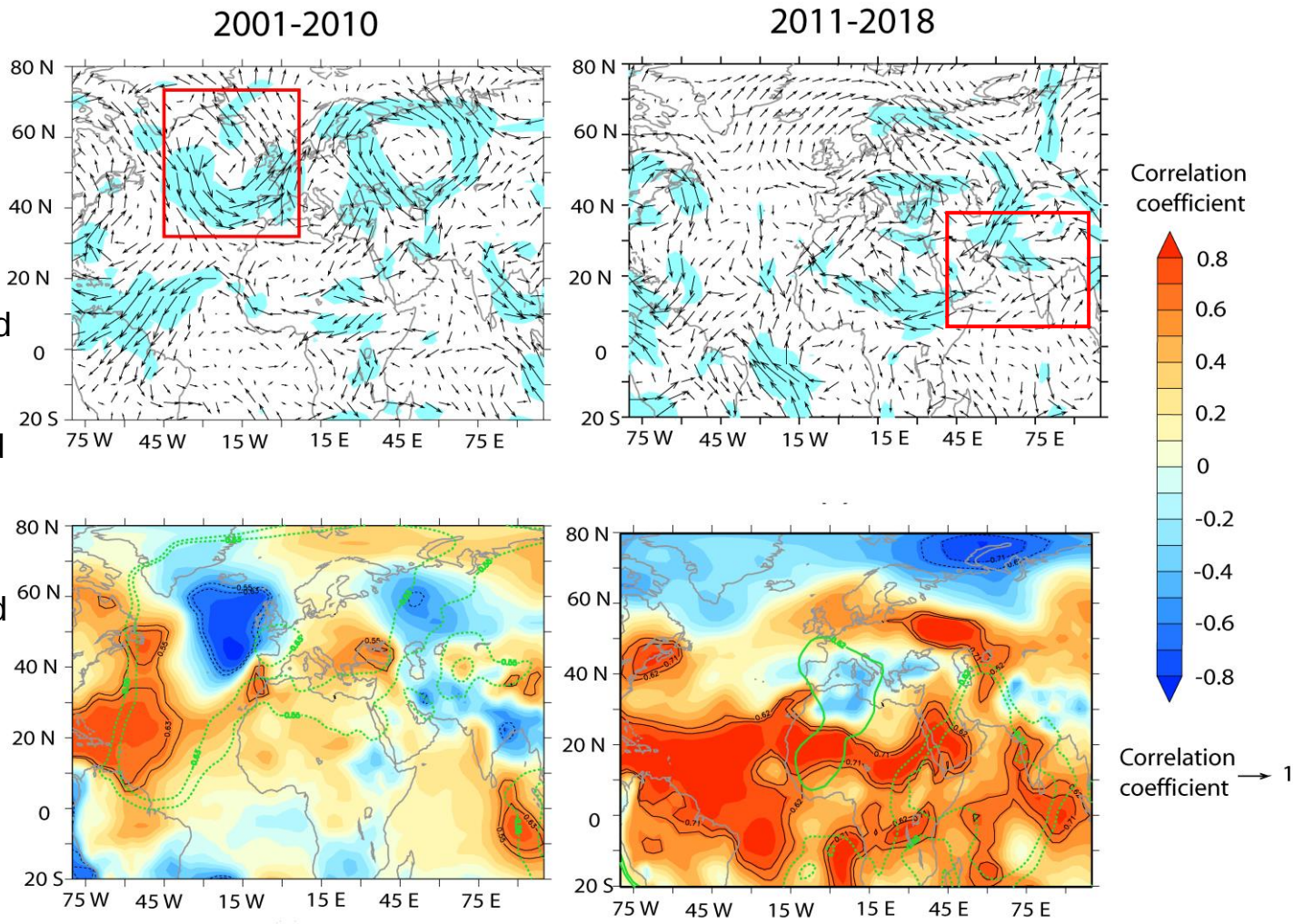


- Signature of global warming hiatus is seen in the slope of SST during 2001-2010.
- With the resumption of global warming since 2011, the North Atlantic SST assumes importance in controlling dust activity over South Asia, indicating a shift from the well-known importance of the Pacific SST. The linkage is through a persistent positive phase of NAO during 2011-2018.

Changing relation between the April-June NADI and different meteorological parameters

Changing relation between NAO and NADI influenced circulation over Eurasia and North Africa.

Over South Asia: increased subsidence and positive anomalies of sea level pressure resulted in weakening of monsoon and strengthening of the dust-transporting westerlies.

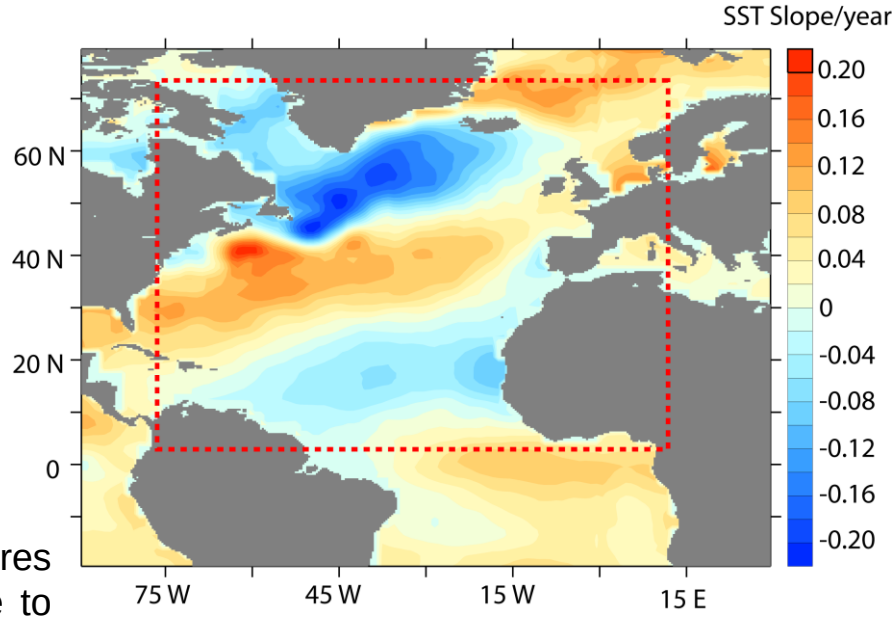


Upper panel: Arrows show correlation between NADI and wind averaged between 850-700 hPa. Light blue shade: regions where one of the components of the wind vector is significantly (95% confidence level) correlated with NADI.
Lower Panel: Shading shows correlation between NADI and SLP and the green contours enclose the regions of significant correlation between NADI and velocity potential at 850 hPa pressure level. Black contours indicate the regions of significant correlation between NADI and SLP. Continuous (dashed) contours: significant positive (negative) correlations; inner and outer contours: 95% and 90% confidence levels respectively.

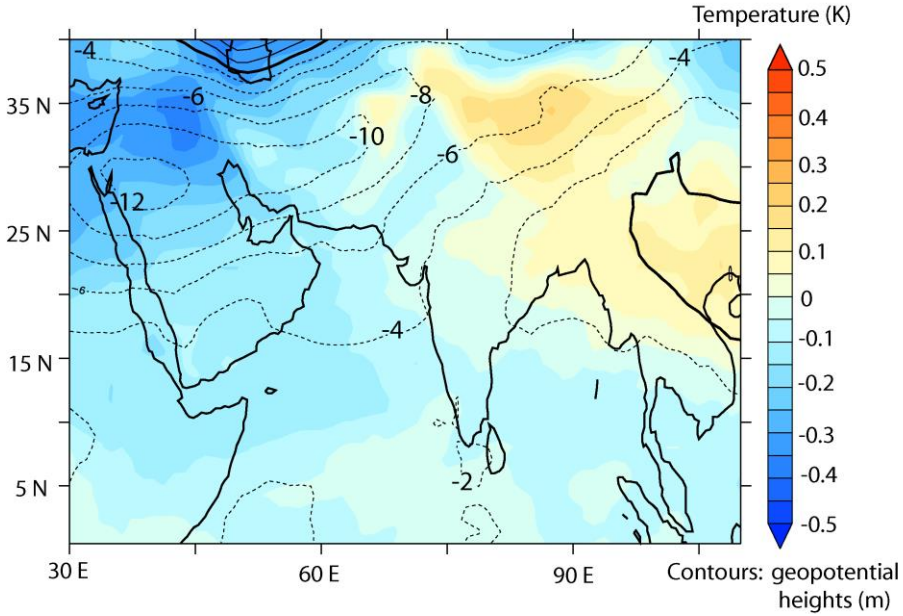
CESM 1.2 experiments

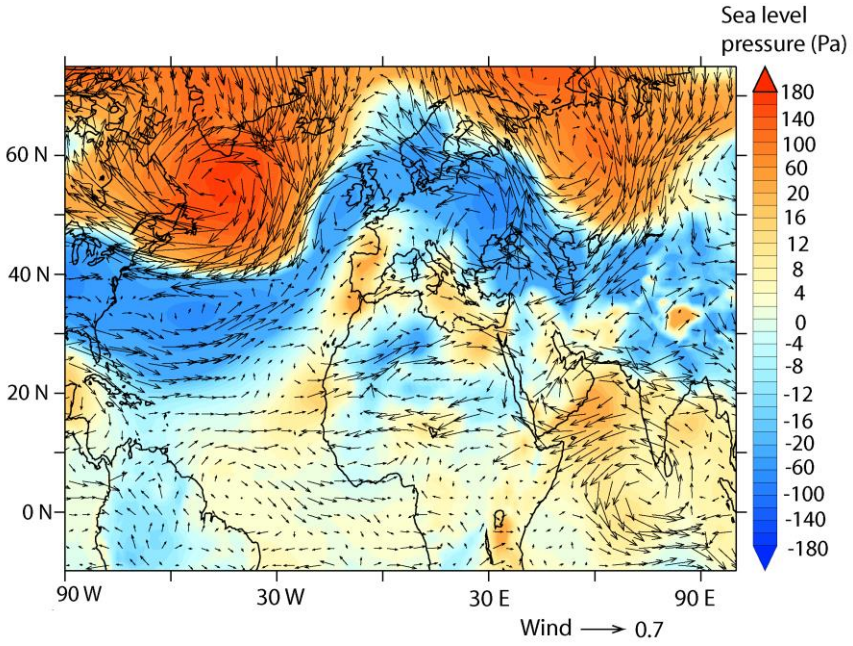
- CAM4-BAM & CLM-SP
- 2 sets of simulations:
  - Ctrl: Climatological SST from Hadley Centre.
  - Natl: SST slope during 2011-2018 imposed only over the North Atlantic.
- Total 15 years for each set of simulation. Last 10 years used.
- NAtl minus Ctrl = influence of North Atlantic SST.

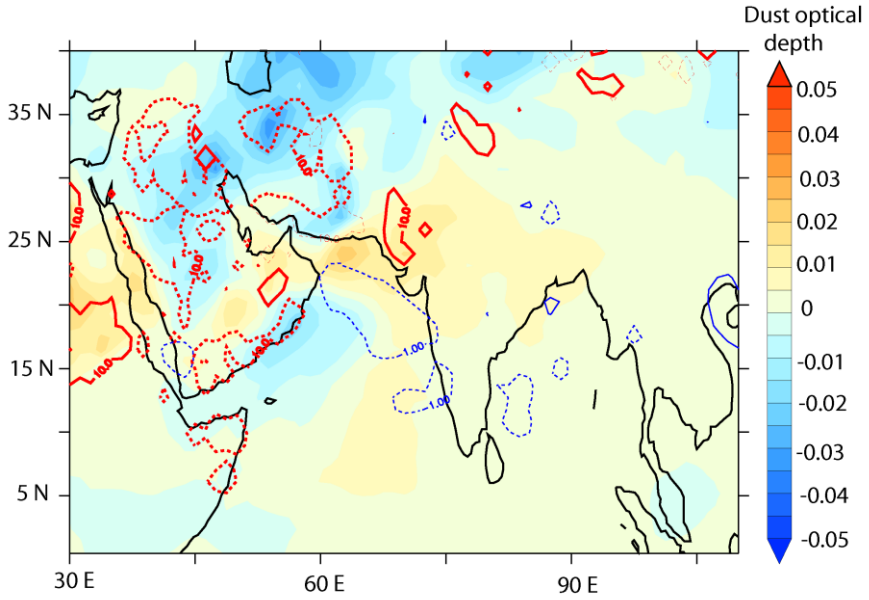
SST slope imposed for NAtl simulation



NAtl minus Ctrl simulations for May-September: Signatures of weakening of South Asian Monsoon circulation due to North Atlantic SST anomalies.



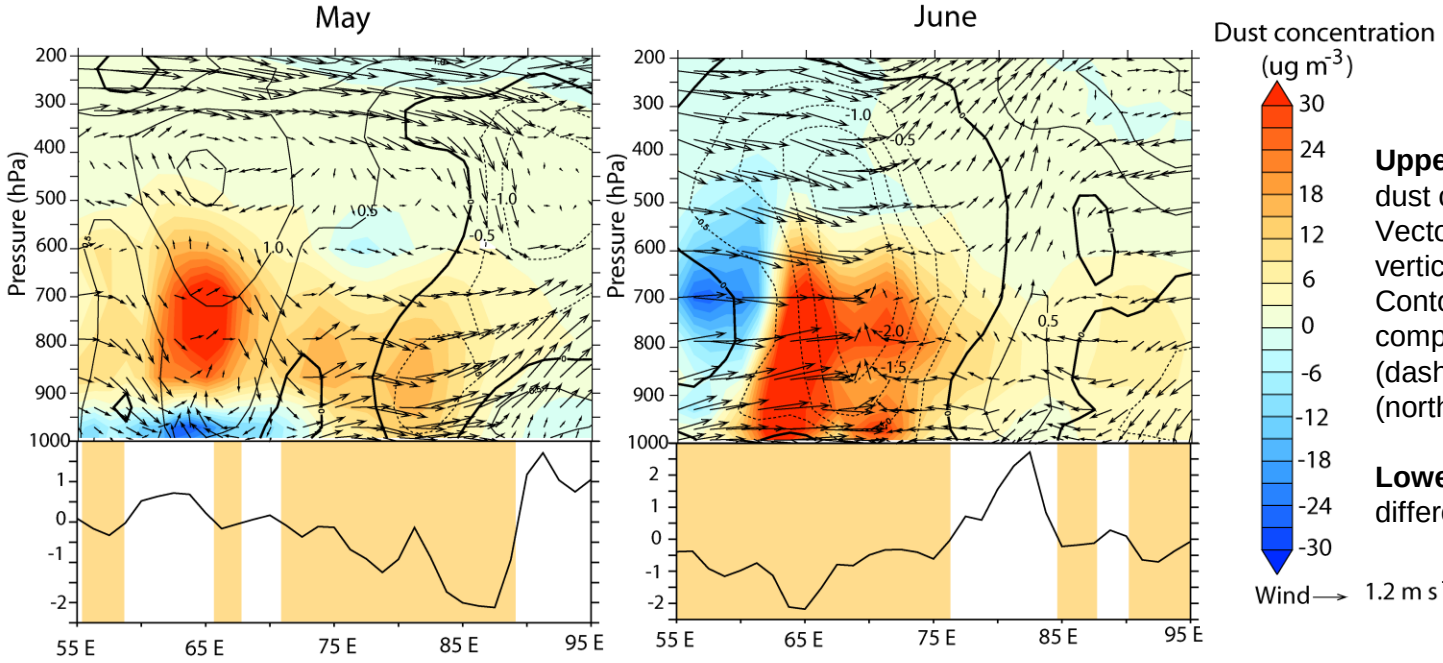




Differences between NAtl and Ctrl simulations for May-September

Shadings: Difference in dust optical depth.
Red contours: Difference in dust emission greater than 10 mg m^2 day^{-1} Blue contours: Precipitation difference is greater than 1 mm day^{-1}.

Differences between Natl and Ctrl simulations along 25ºN latitude



Upper panel: Shadings: difference in dust concentrations,
Vectors: difference in zonal and vertical components of wind.
Contours: difference in meridional component of wind. Continuous (dashed) contours indicate southerly (northerly) wind.

Lower panel: Precipitation differences, in mm day^{-1}

Conclusions

- The North Atlantic SST is driving the interanuual variability of South Asian dust since 2011.

- This is accompanied by persistent positive phases of NAO and end of the early 21st century global warming hiatus .

- Changing relation between NAO and North Atlantic SST in recent years has resulted in weakening of the South Asian monsoon and intensification of dust-carrying westerlies.

- Longer term data needs to be studied to understand how the relation between dust and North Atlantic SST has fluctuated over time.

Thank you !!!!