Factors driving the persistence of ENSO-led winter rainfall deficits into late-spring and early-summer over Texas

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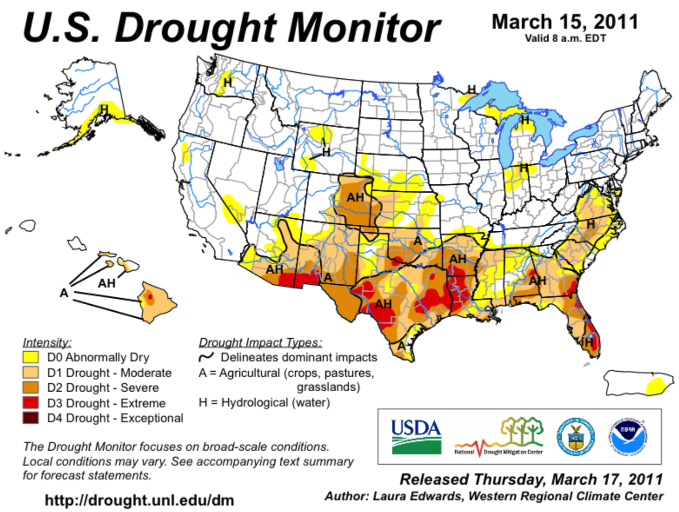
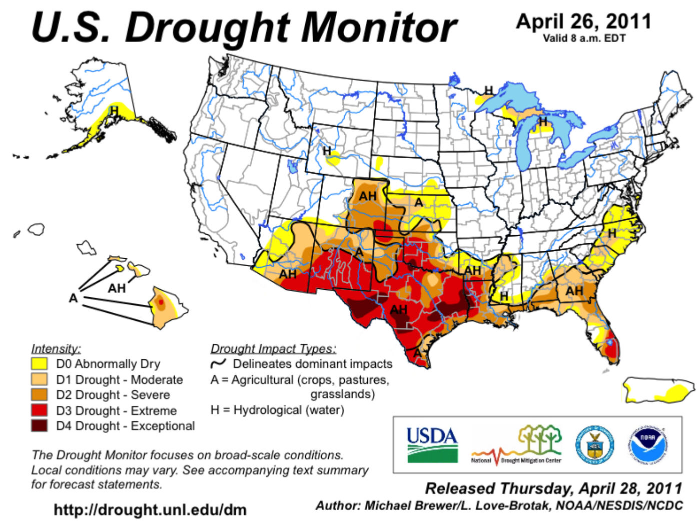
2011 Texas drought highlights

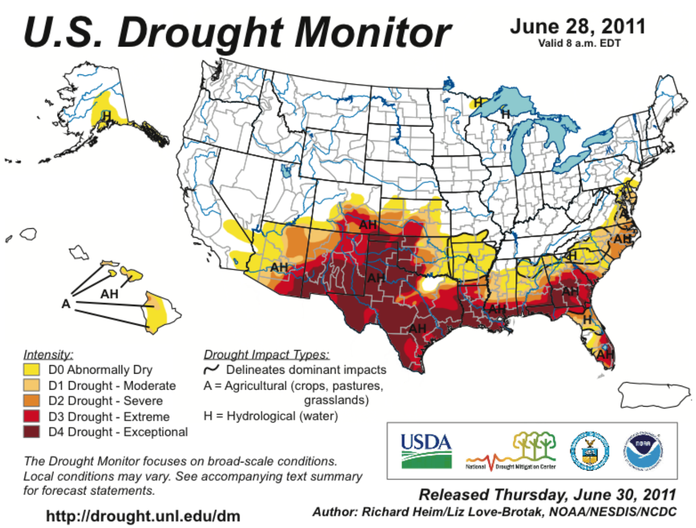
1. Record temperatures: spring through summer
2. 40% of normal precipitation
3. $7.6 billion agricultural losses
4. Lowest reservoir storage (down to 58%) in November 2011
5. Rapid intensification in spring

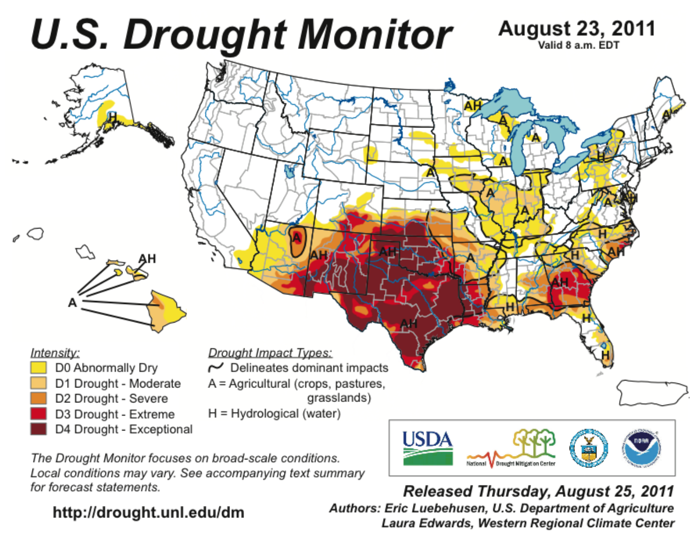
Rapid intensification in late-spring





Mar-May: 51% of normal





June-Aug.: 37%

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Research questions

1. What caused the spring intensification of the 2011 drought event?

2. Is spring intensification a common characteristic in extreme drought years?

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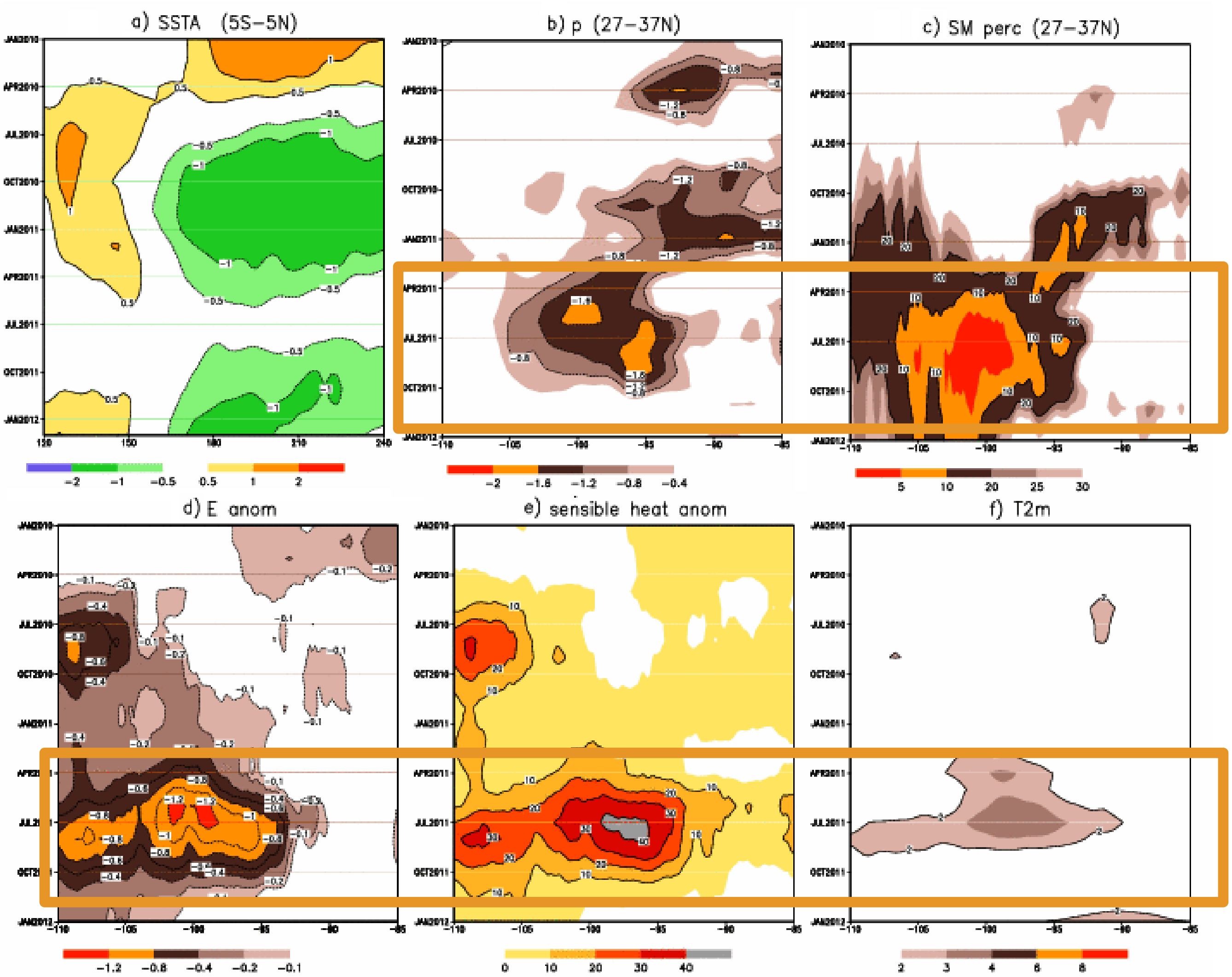
Factors driving the persistence of ENSO-led winter rainfall deficits over Texas

SSTAs, soil moisture and surface temperature anomalies



Source:
Dr. Kingtse Mo in Fernando et al., (in-prep)

Drivers of spring rainfall deficit

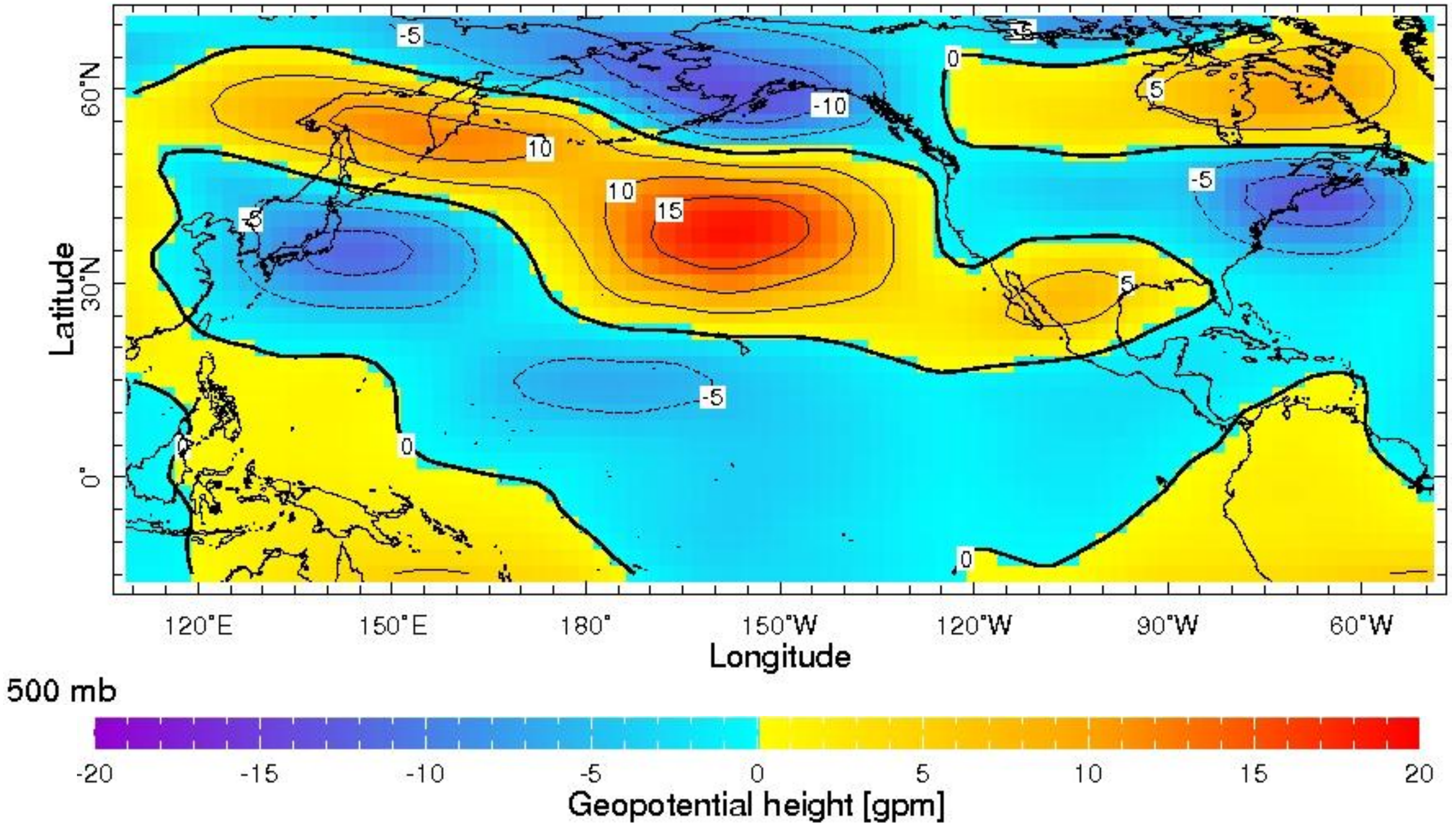
1. Large-scale circulation anomalies
   - *i.e. ridging at 500 hPa due to large-scale subsidence*

2. Local thermodynamic conditions
   - *i.e. factors affecting convective inhibition (CIN)*

3. Synoptic conditions (as triggers in rainfall inhibition)

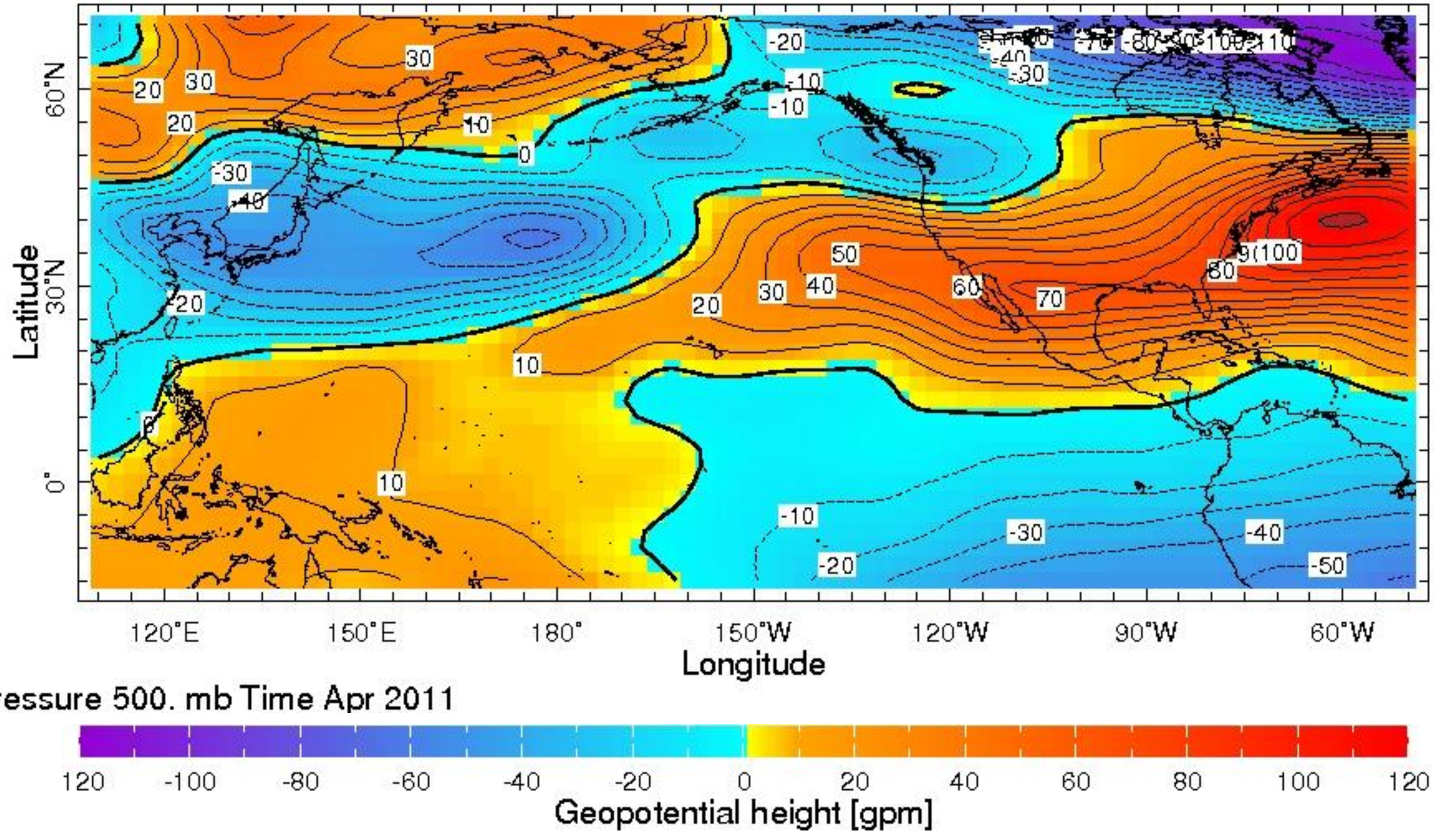
Large scale subsidence: *La Niña as a driver of the 500 hPa high?*

Composite of April 500 hPa height anomalies in 23 La Niña years

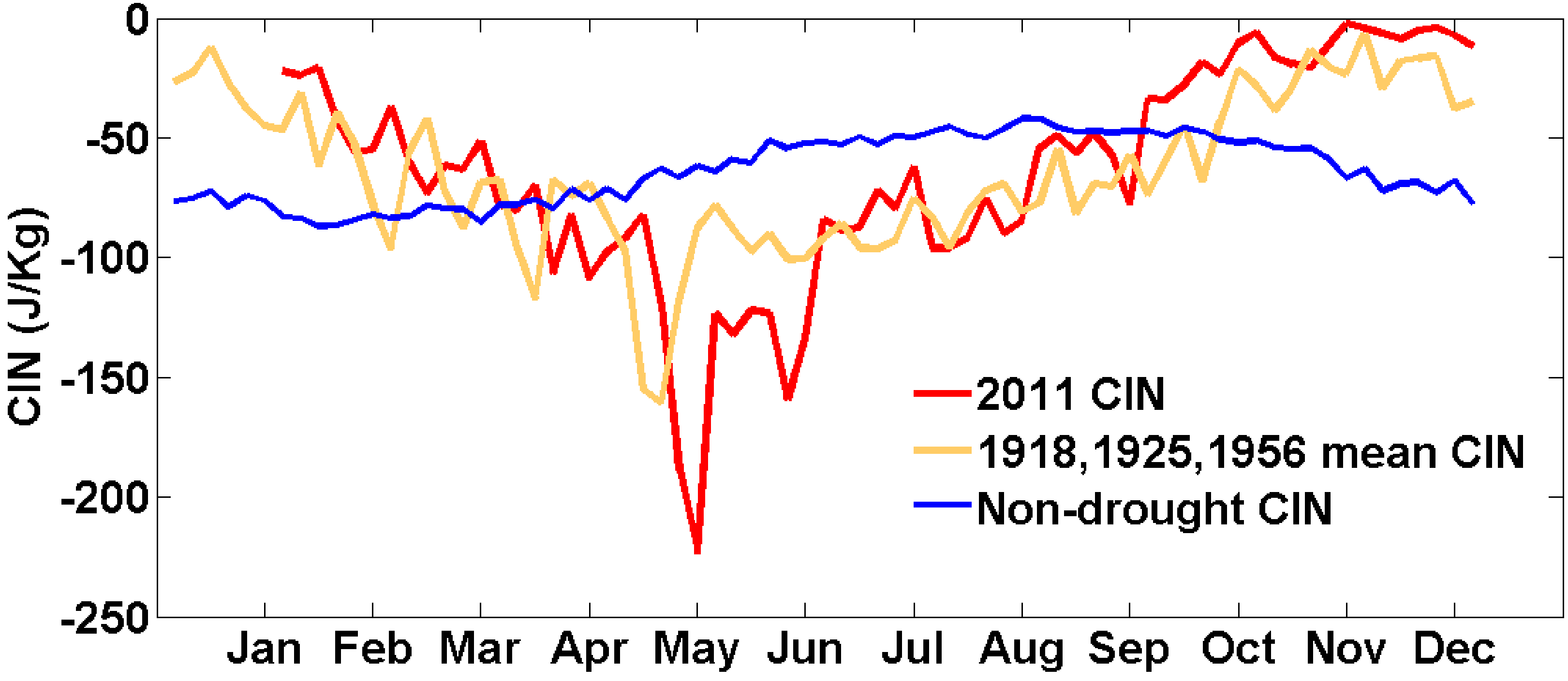


2011 April 500 hPa high: *similar La Niña signal?*

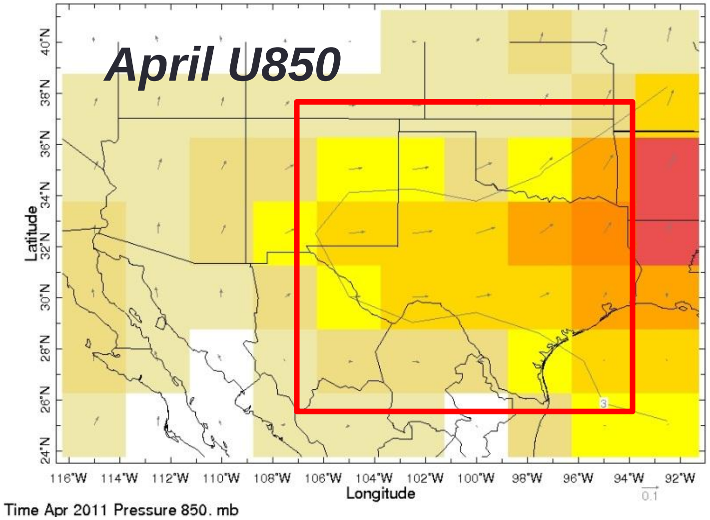
Similar high pressure over South Central US but more zonal over Pacific



Local thermodynamic conditions:
sudden increase in CIN

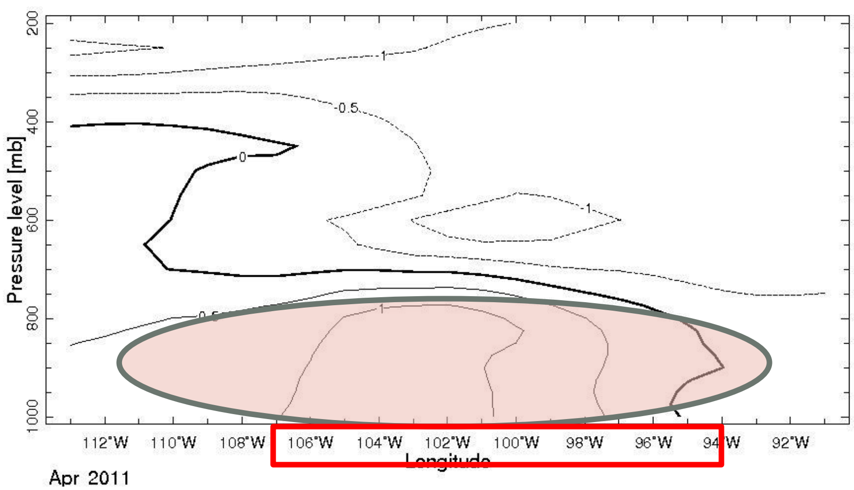


Synoptic conditions as triggers for spring onset of summer drought?

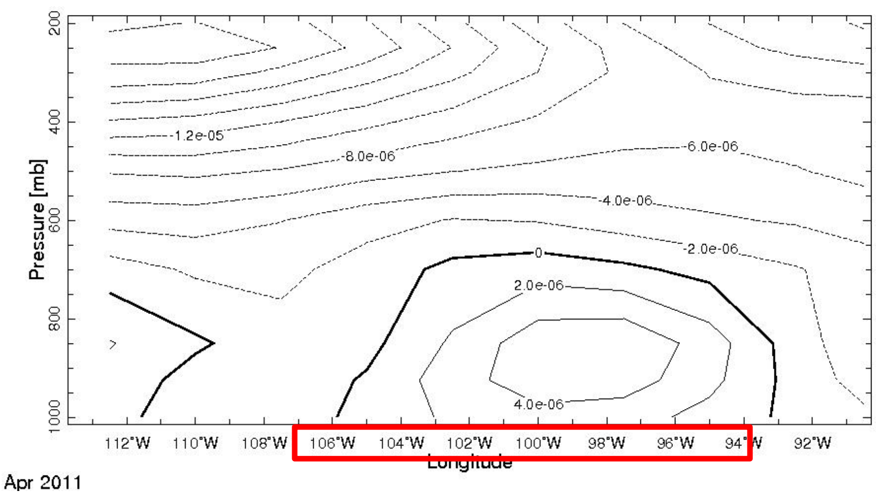


Anomalous zonal winds at 850 hPa in April 2011

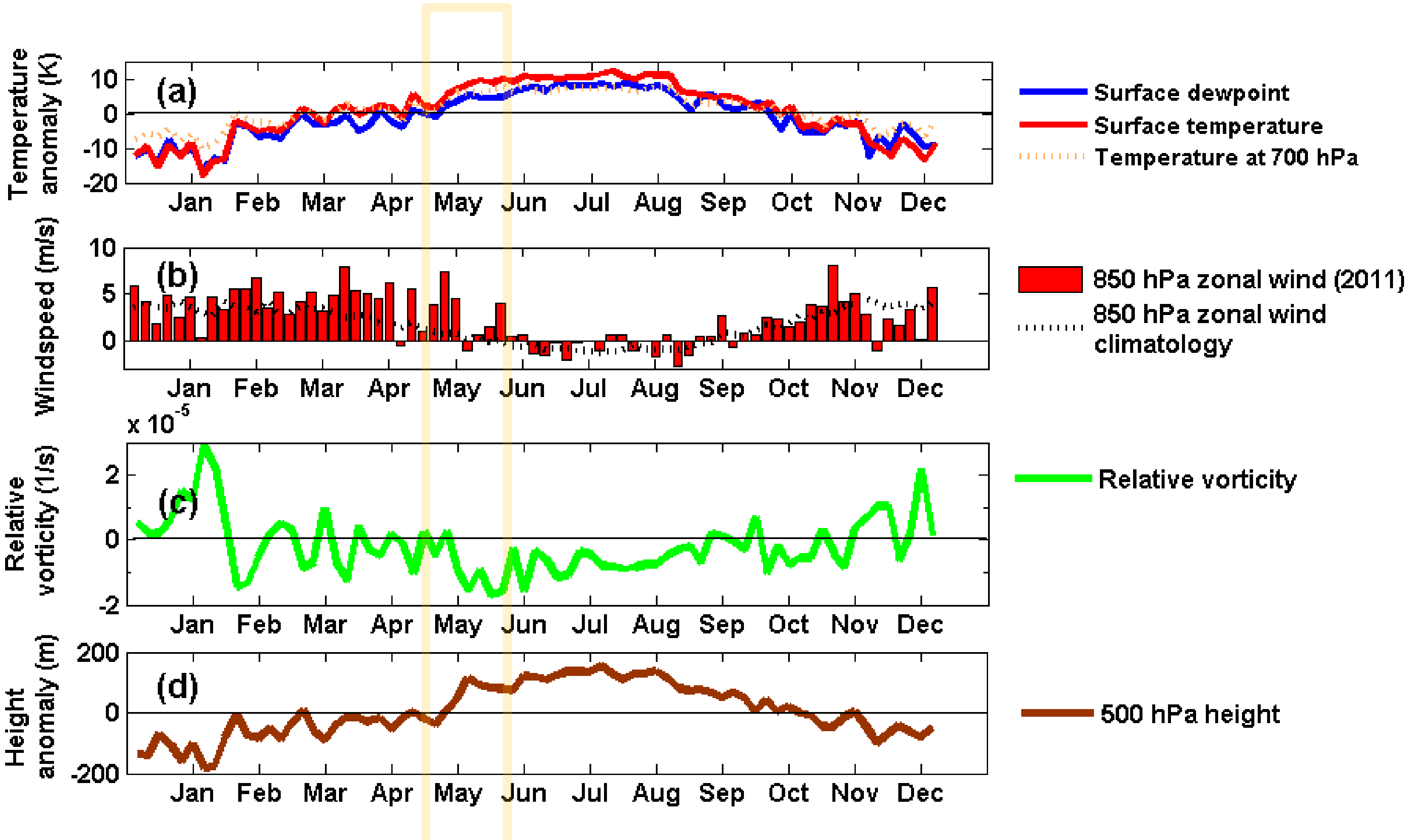
April 2011 potential temperature profile



April 2011 relative vorticity profile



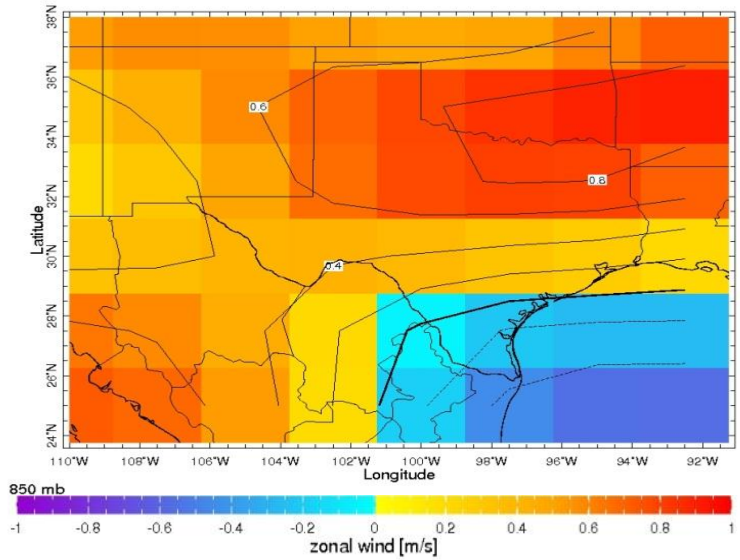
Synoptic conditions and land surface forcing of 500 hPa height?



Is spring intensification common in extreme drought years?

- Yes. There is a preference for dry summers to follow dry springs
- **Persistent rainfall deficits in DJF, MAM and JJA** in **12 of 18 severe-to-extreme droughts**, and 6 of 10 moderate droughts
- **Strengthened U850 in April** in the **12 severe-to-extreme** drought years with **DJF_{dry}|MAM_{dry}|JJA_{dry}**

Composite U850 wind anomaly



Top right: April U850 composite in 12 severe-to-extreme drought years with DJF_{dry}|MAM_{dry}|JJA_{dry}

Summary of key processes

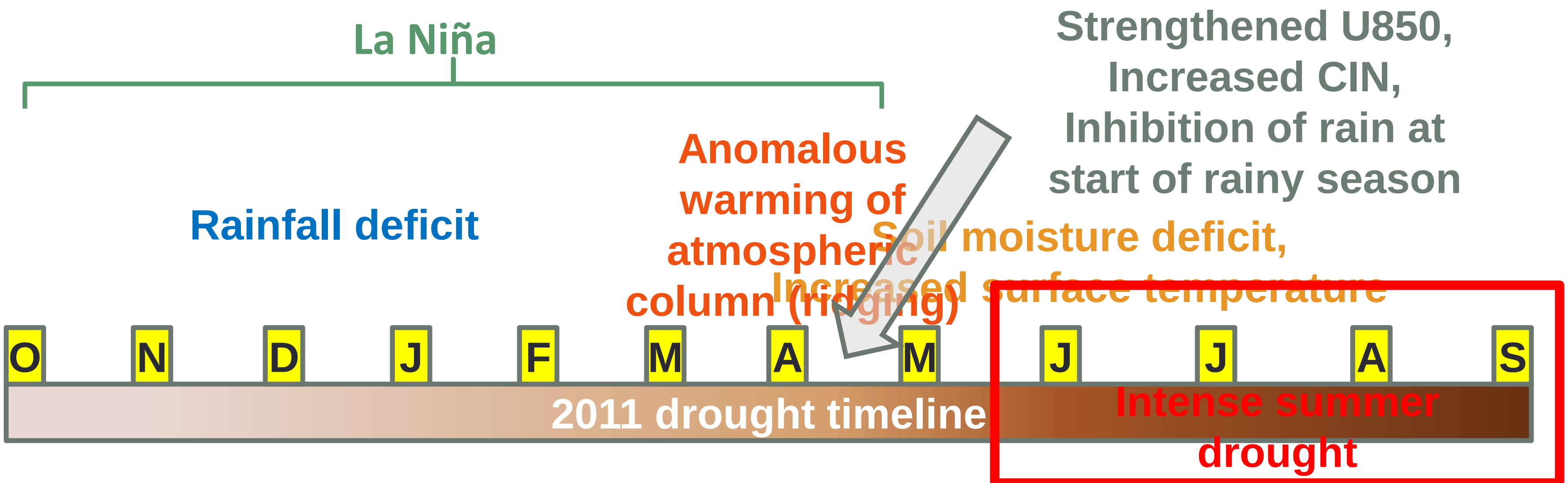
1. Decrease in cumulative column soil moisture from winter through spring (maximum decreases in April and in JJA)
   - ***Increases in sensible heating and surface temperature***

2. La Niña-induced large scale subsidence (500 hPa ridging) in spring

3. Increases in CIN in late-spring

Causes for increased CIN

4. Strengthened westerlies at 850 hPa in April
    - *Advect warm and dry air eastward > sharp increase in CIN (late-April and early-May)*
    - *Increase in surface and 700 hPa temperature*
    - *Depression in surface dewpoint (soil moisture depletion from advective drying)*
    - *Increased z500 hPa (more stability and descent)*



Conclusion and future work

1. Strengthened westerlies at 850 hPa in April during intense drought events has implications for drought predictability

2. When drought is established in winter/spring, soil moisture feedback can influence drought intensity
   - *Need for improved soil moisture monitoring*
   - *Implications for agriculture and water resources*

Under investigation:

Could Rossby wave propagation and/or intraseasonal variability (i.e. perhaps MJO-influenced) drive the sudden intensification of April U850?

Acknowledgements

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