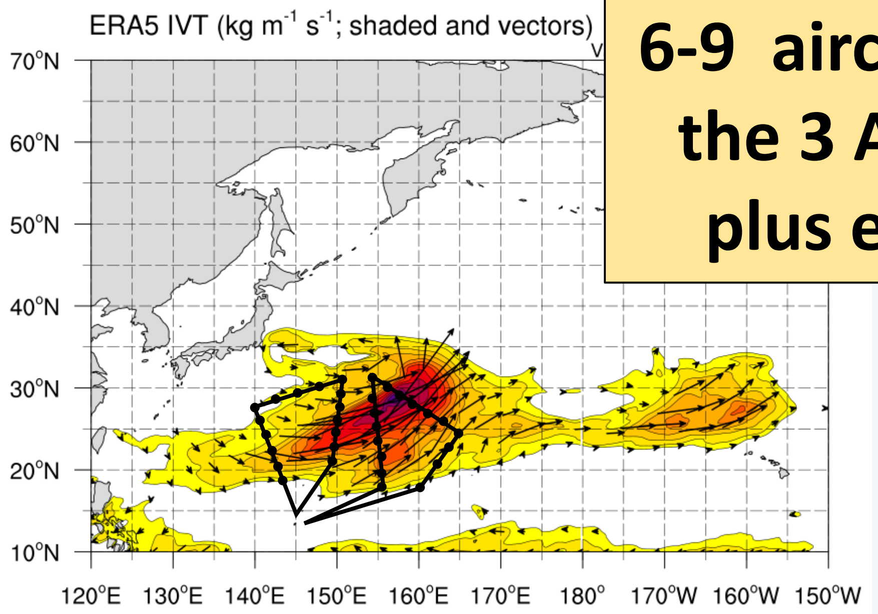
Winter 2025/26: “GARRP – Pilot Study”

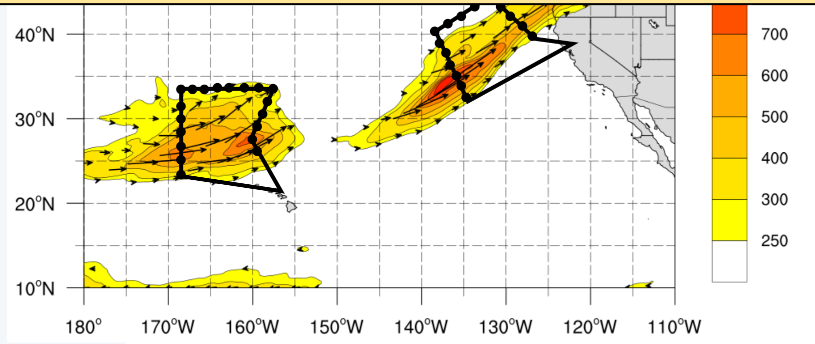
Jan-Feb 2026 GARRP Demo

6-9 aircraft simultaneously sampling the 3 ARs in the two ocean basins, plus extra radiosondes over land

WestPac

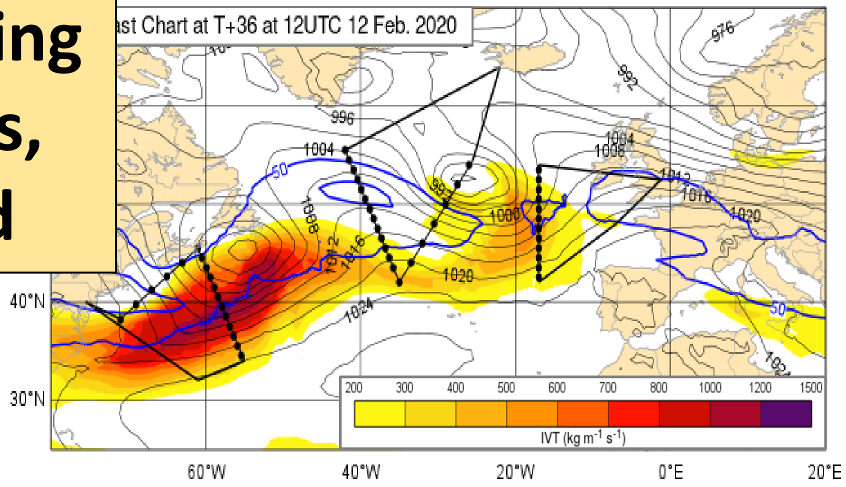


- **Full Demo**
- **6 weeks** during Jan–Feb 2026
- 2 AF C-130s, **plus an international partner aircraft (South Korea, Japan…?)**



- Full Season
- 1 Nov – 31 Mar
- 4 Aircraft (3 AF C-130s and 1 NOAA G-550)

Atlantic



Lavers, D.A., F.M. Ralph, D.S. Richardson and F. Pappenberger (*Communication Earth Environ,* 2020)

- **NAWDIC****
- Jan–Feb 2026
- 1 AF C-130, plus **2 European aircraft for 5 IOPs, simultaneous with EastPac and WestPac IOPs**

***with one AF C-130 sampling ARs over Gulf of Mexico or off U.S. East Coast for Nor’Easters, and coordinated radiosonde launches from both NWS and University partners*

Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

GARRP = Global Atmospheric River Recon Program
NAWDIC = North Atlantic Waveguide, Dry Intrusion, and Downstream Impact Campaign

Improved forecasts of atmospheric rivers through systematic reconnaissance, better modelling, and insights on conversion of rain to flooding

Lavers, D.A., F.M. Ralph, D.S. Richardson and F. Pappenberger (*Communication Earth Environ,* 2020)

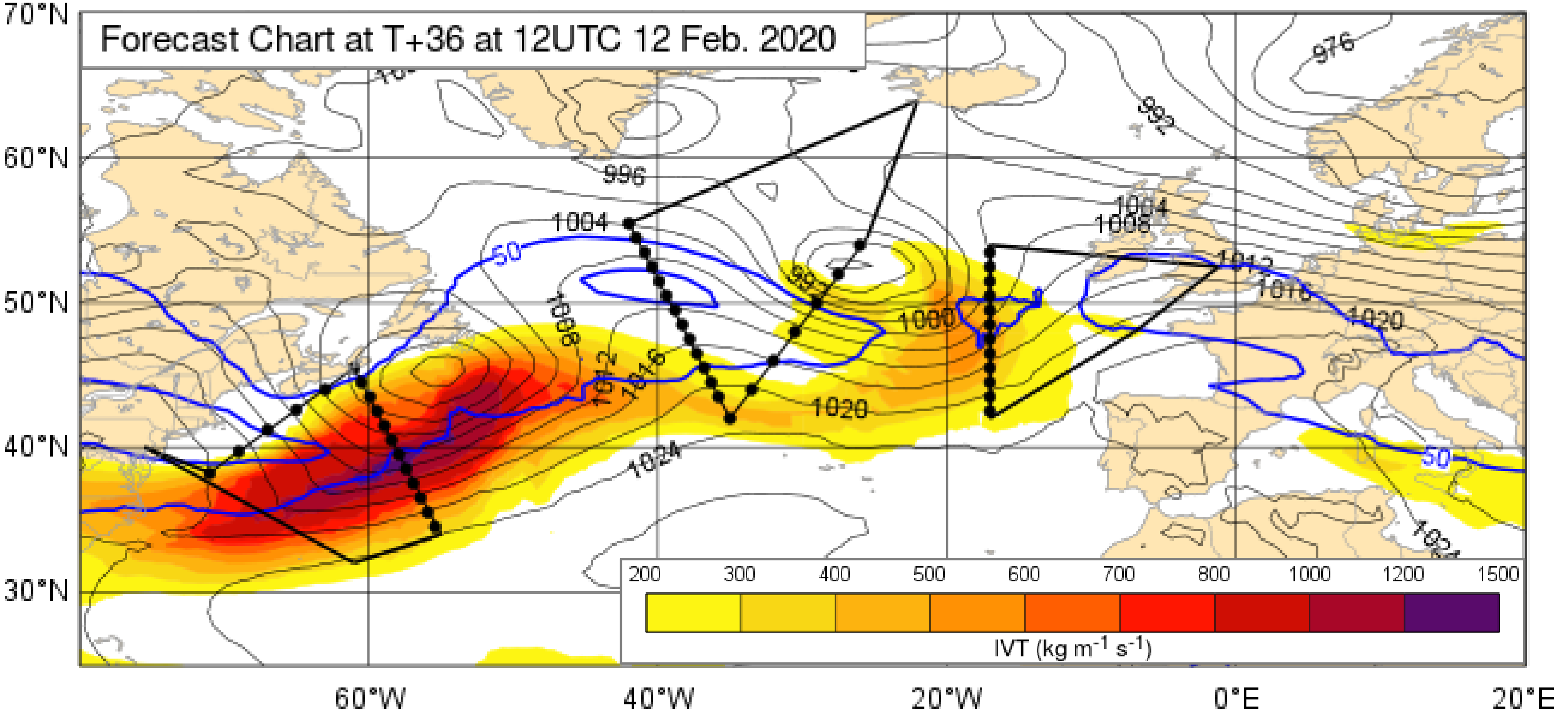
Proposes a joint European–American observational campaign building on AR Recon and NAWDEX

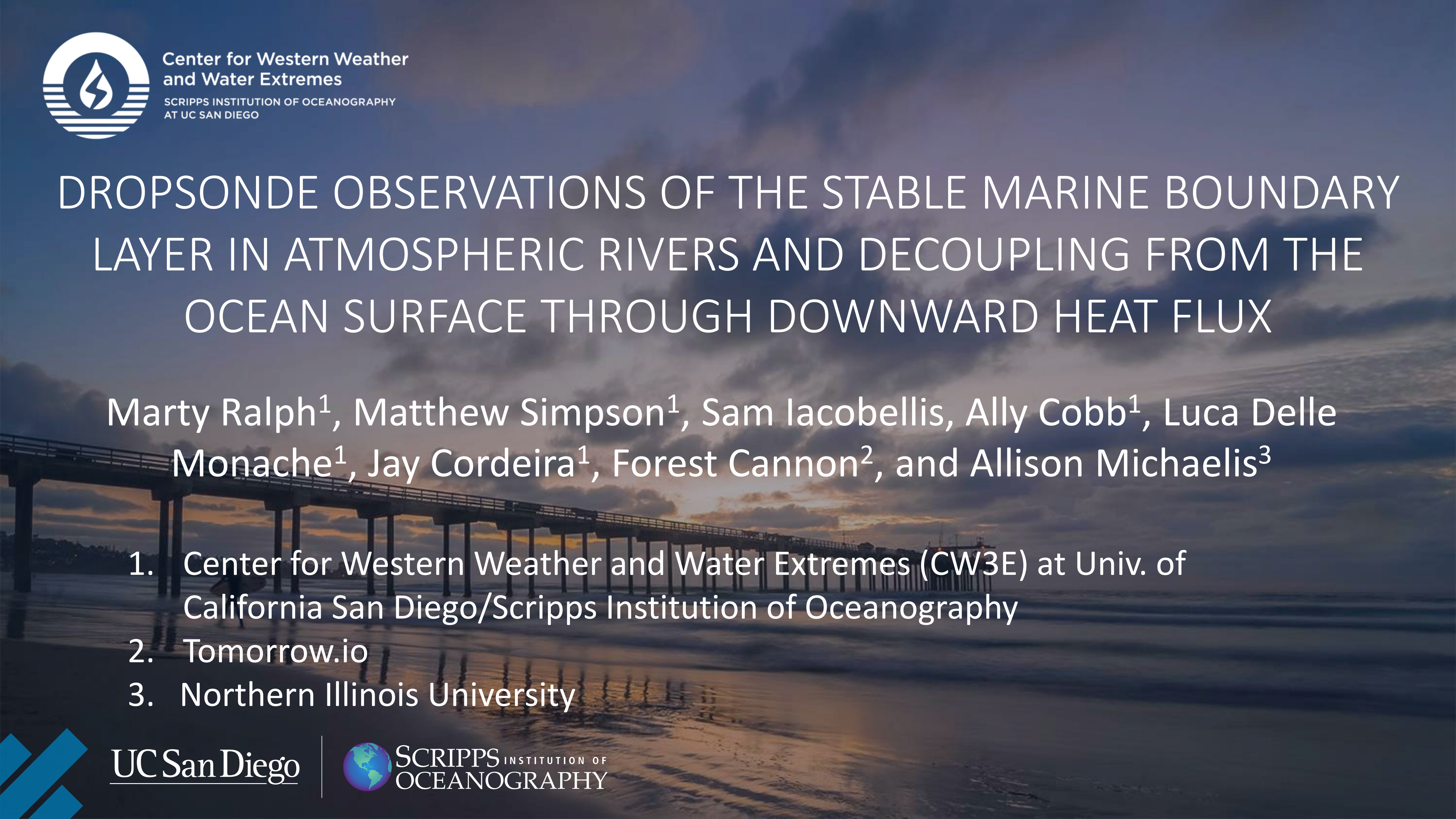
NWP modelling improvements including use of extra observations.

Investigate how river basin properties affect the rainfall to river discharge conversion.

CW3E

ECMWF


Forecast Chart at T+36 at 12UTC 12 Feb. 2020



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DROPSONDE OBSERVATIONS OF THE STABLE MARINE BOUNDARY LAYER IN ATMOSPHERIC RIVERS AND DECOUPLING FROM THE OCEAN SURFACE THROUGH DOWNWARD HEAT FLUX

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Motivation for Research

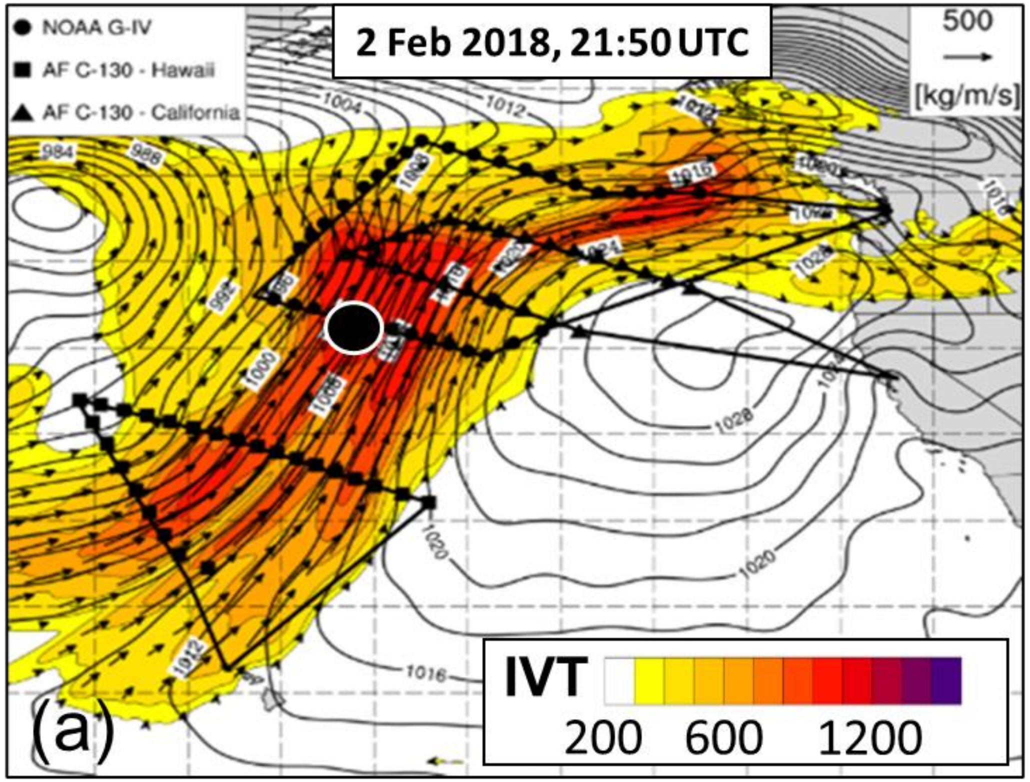
- ECMWF initial analysis differs from dropsonde observations most at the top of MBL (Layers et al., 2018)
- In assimilating ocean surface observations (e.g., from buoys, satellites) it can be unclear how far upward the information should impact the atmosphere above the surface
- Quality observations will be rejected during data assimilation if the model error (i.e., background state) is too large
- Understanding MBL structure in association with atmospheric rivers is imperative to improving data assimilation

High-resolution obs are needed for MBL stuides

- Studies of the stable boundary layer structure over the ocean have been restricted due to the limited availability of quality, high-resolution observations, and to the greater emphasis on cold-air-over-warm-water condition (e.g., lake effect snow)
- Observations from ships and buoys normally do not provide information over the depth of the MBL
- Remotely sensed MBL data typically have large observation errors and lack sufficient vertical resolution for detailed MBL studies
- Investigations of AR airmass modification where warm (lower-latitude) air is transported over increasingly cooler water requires high-resolution observations

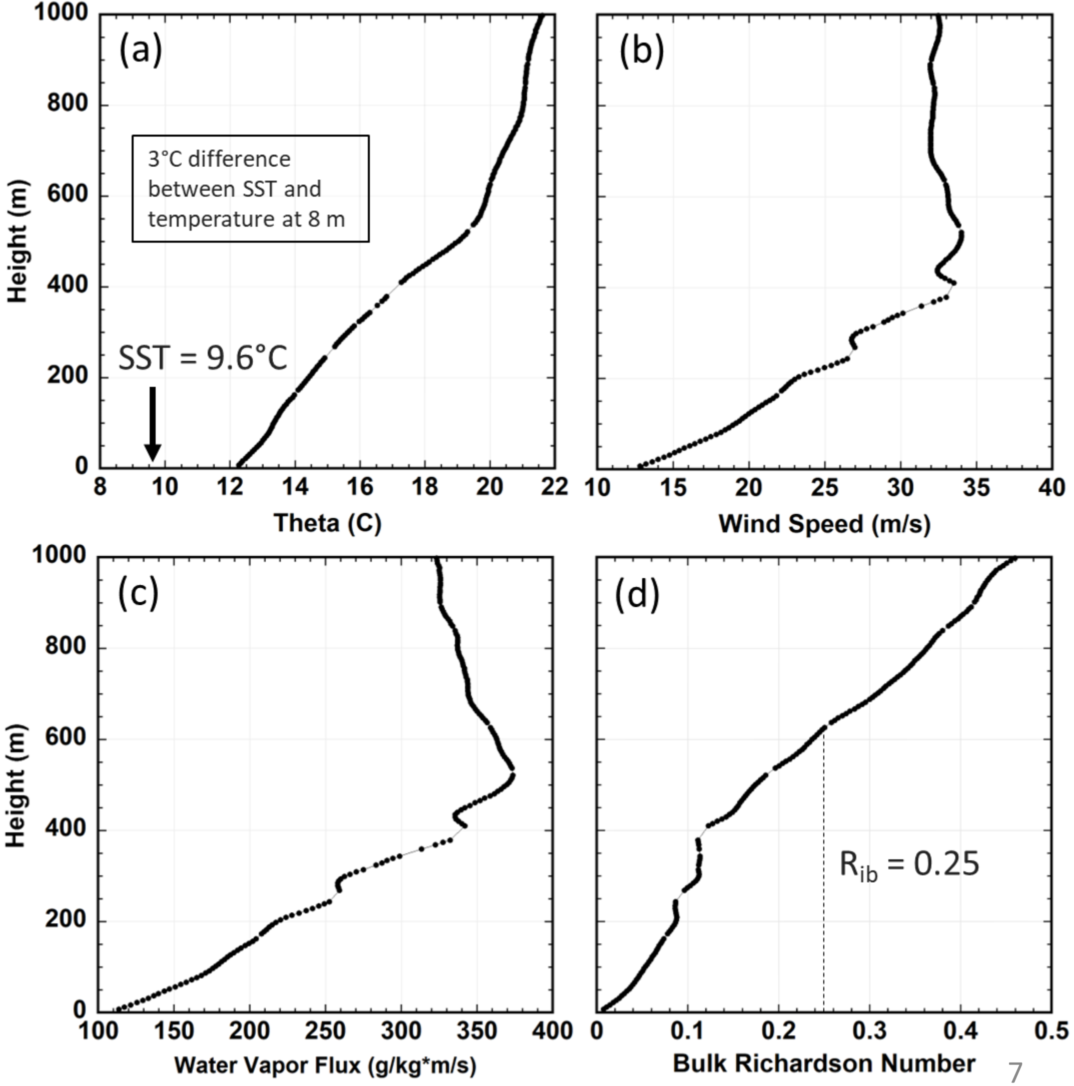
Dropsondes released during AR Recon program provide valuable data on MBL dynamics

Marine boundary layers beneath ARs exhibit a complex structure



● **Demonstration dropsonde location**

Dropsonde profiles from AR core



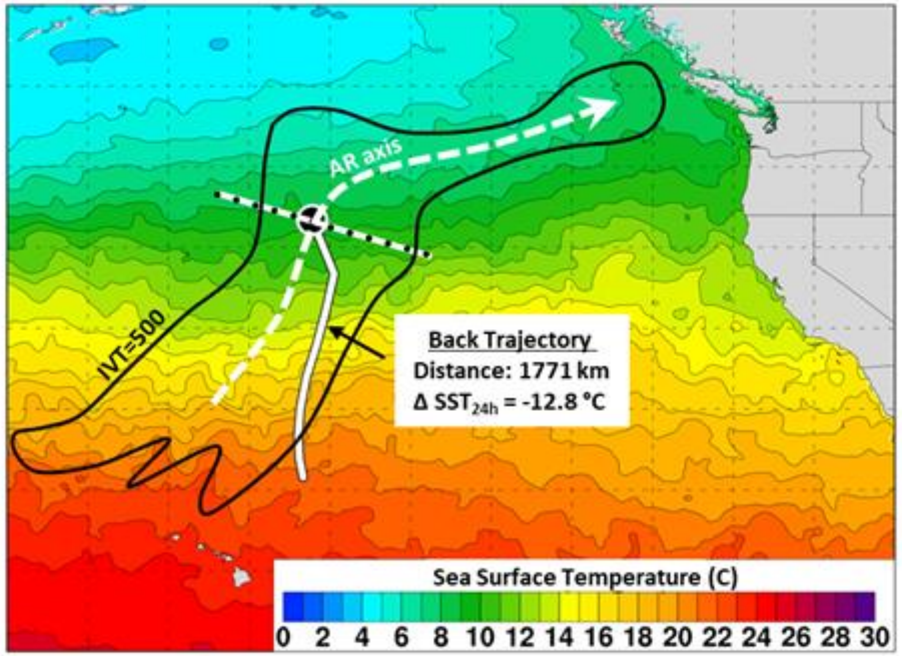
Research overview

Hypothesis

It is expected that ARs on average transport warm air poleward. As a result, the air-sea interface beneath an AR generally loses sensible heat to the increasingly cooler ocean surface below it resulting in the development of a complex MBL structure.

Methodology

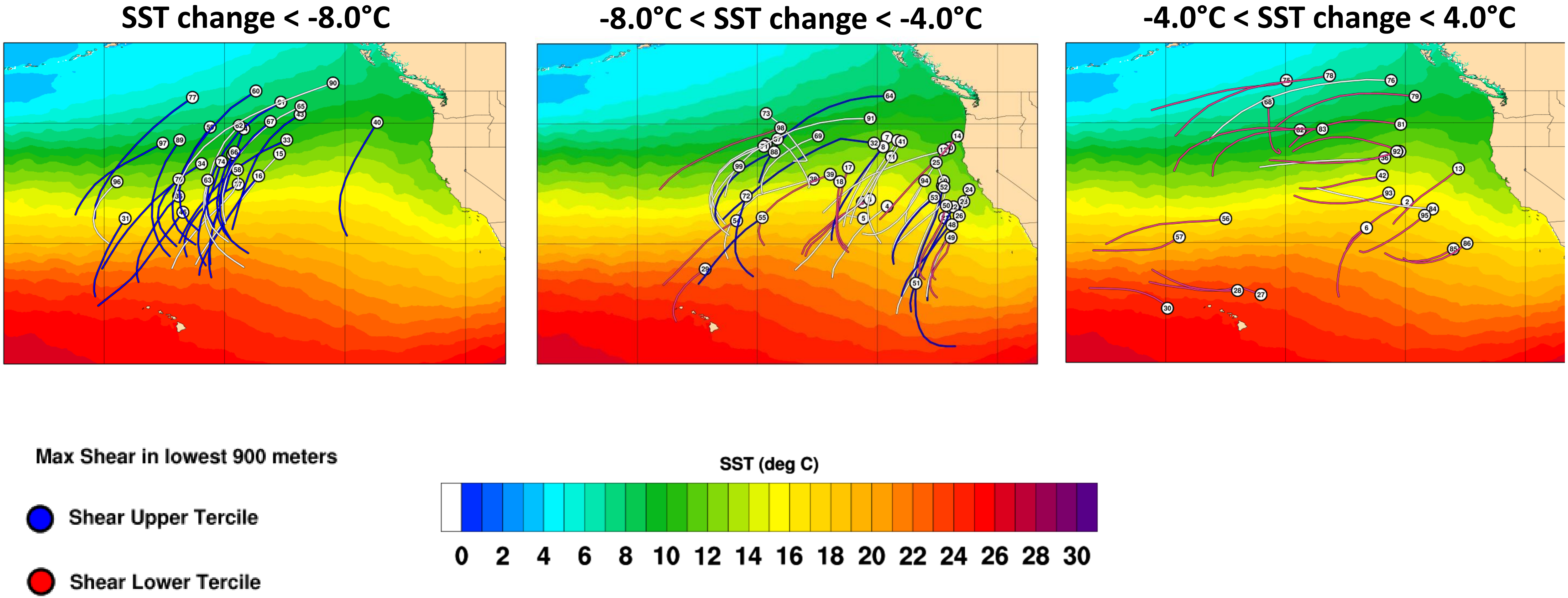
Back trajectories originating from dropsonde locations within the AR core were used to calculate the 24-hour change in sea surface temperature experienced by the AR airmass as it moved over (normally) colder water. Each AR is characterized as having a weak or strong air-sea decoupling regime based on the magnitude of the delta SST associated with the 24-hr back trajectory.



Sample 24-hr back trajectory calculated using HYSPLIT and gridded reanalysis data

"**Delta SST**" is the 24-hour change in sea surface temperature experienced by the AR airmass as it moved over (normally) colder water beneath it

Calculated 24-hr back trajectory SST change



SST change < -8.0°C

-8.0°C < SST change < -4.0°C

-4.0°C < SST change < 4.0°C

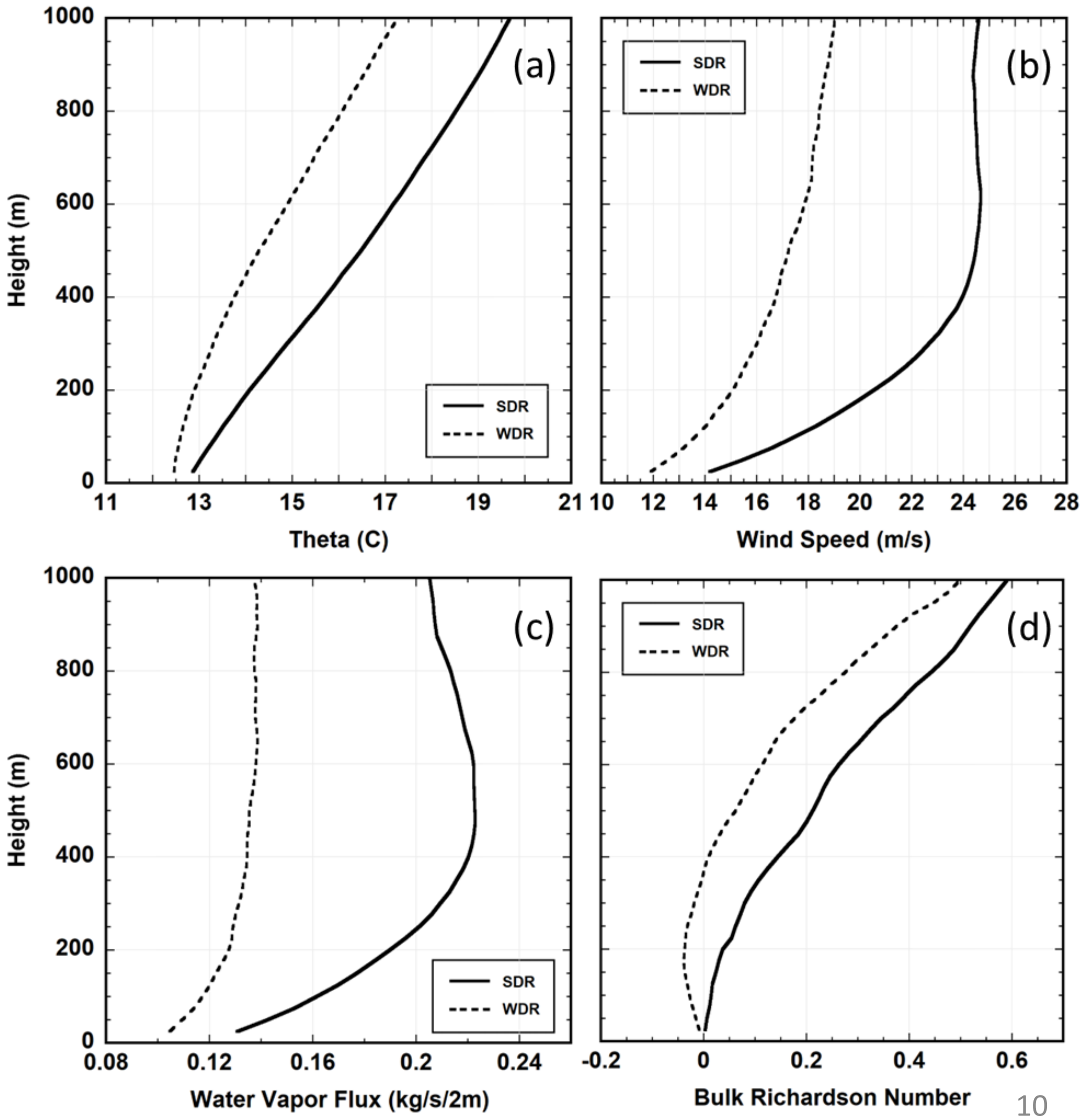
MBL decoupling regimes based on 24-hr SST change

Two MBL decoupling regimes were defined based on the SST change analysis.

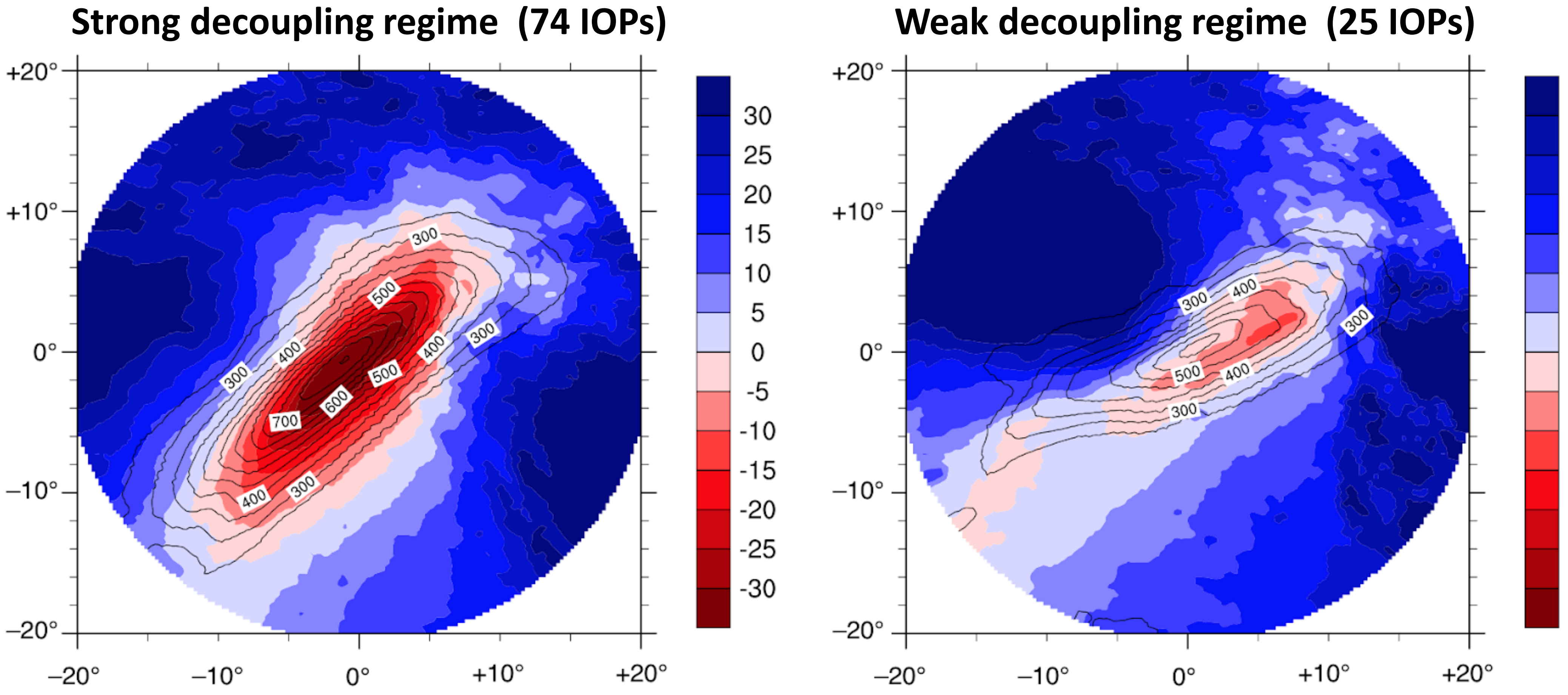
Strong decoupling regime (SDR)
Characterized by a large change in 24-hr SST temperature of air parcel back trajectories originating from an AR core. We define the SDR as a change in SST of less than -4.0°C.

Weak decoupling regime (WDR)
Identified by a small magnitude change in SST (-4.0° to 4.0°C) along the back trajectories.

Significant differences in SDR and WDR composite AR profiles of stability, wind speed, and moisture flux are identified



Greatest downward sensible heat flux is associated with SDR

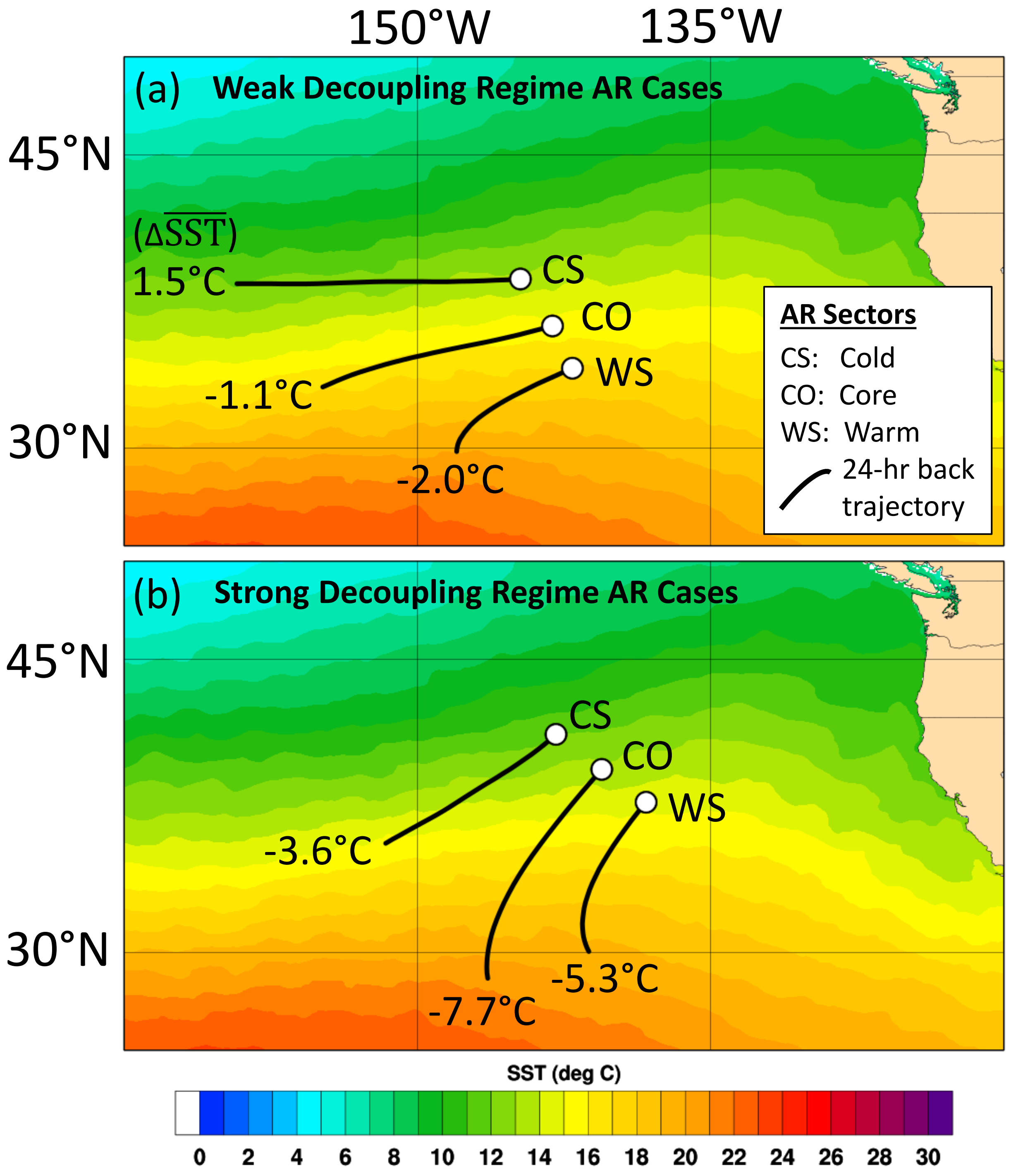


Strong decoupling regime (74 IOPs)

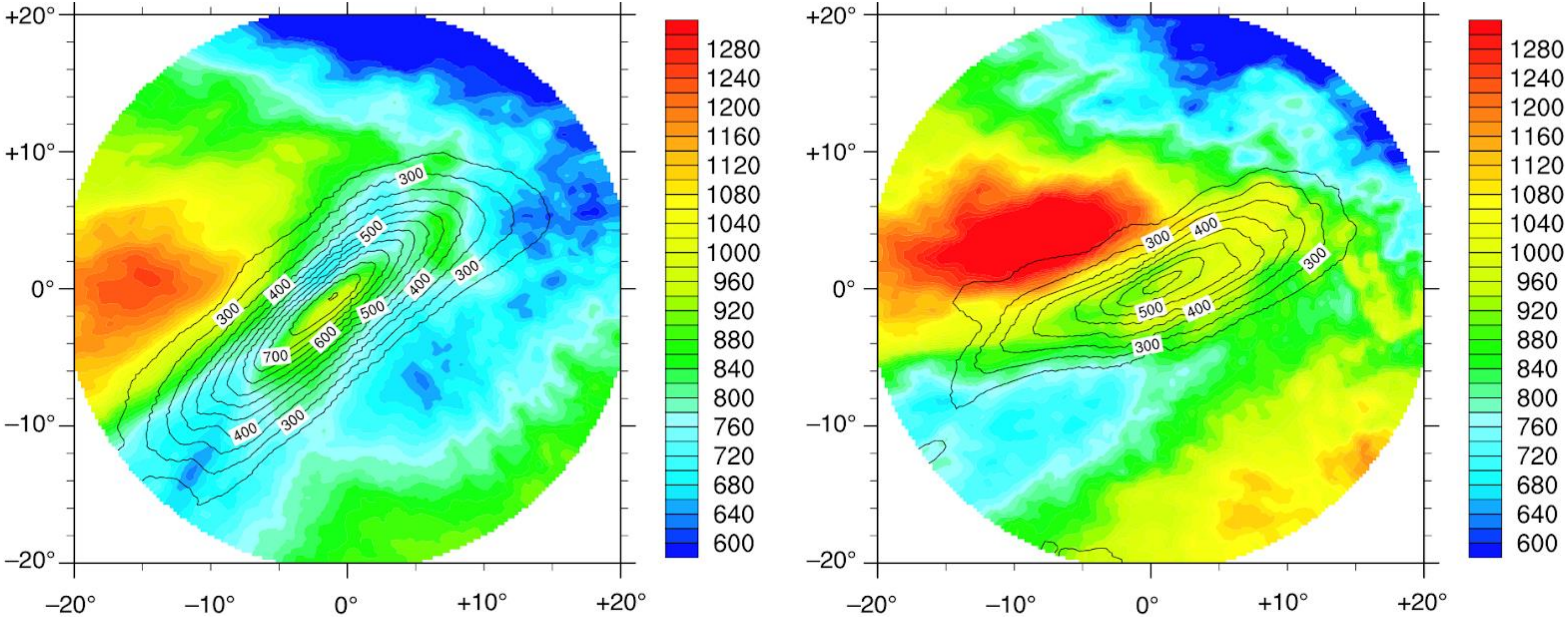
Weak decoupling regime (25 IOPs)

ERA5 derived spatially centered and rotated composite analysis of downward sensible heat flux (W/m2) and IVT magnitude (kg m-1 s-1)

Composite 24-hr back trajectories by AR sector



Highest SDR AR boundary layer heights are in the core



Strong decoupling regime

Weak decoupling regime

ERA5 derived spatially centered and rotated composite analysis of boundary layer height (m) and IVT magnitude (kg m-1 s-1)

MBL decoupling schematic

Panel A

Map showing an AR with composite 24-hr back trajectories from the cold and warm sector and core. A to A’ represents a cross AR transect while B to B’ is the along AR transect.

Panel B

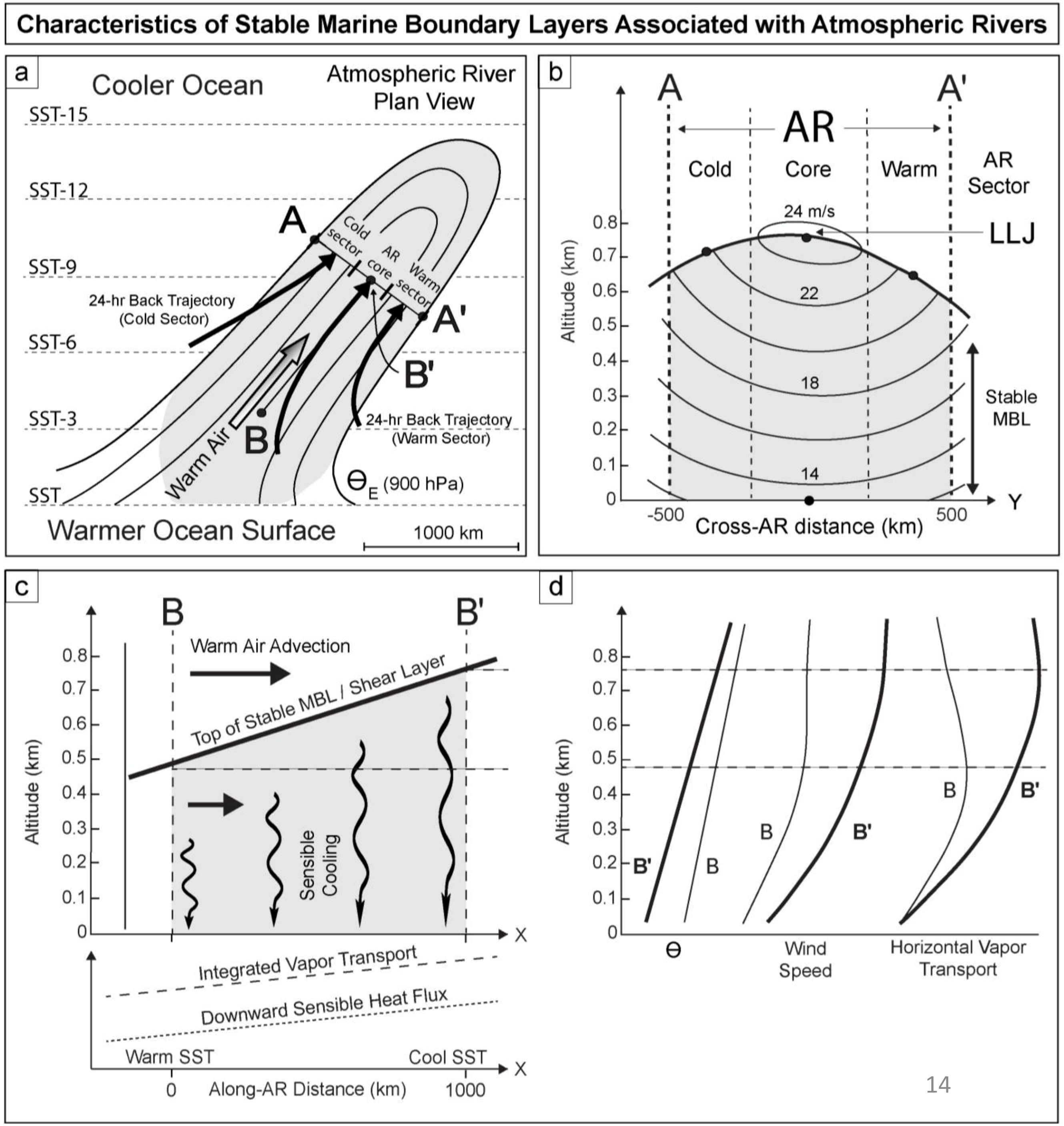
AR cross section of wind speed within the MBL with the jet max shown in the AR core. Lower MBL heights in the warm sector result in a complex wind speed structure.

Panel C

Along AR cross section showing downward sensible heat flux increases towards the core.

Panel D

Variation of stability, wind speed, and moisture transport profiles for the along AR transect.



Characteristics of Stable Marine Boundary Layers Associated with Atmospheric Rivers

Key findings

- The dropsonde analysis reveals the complex structure of the stable MBL beneath ARs and highlights the increase in air-sea decoupling due to advection of the warm air mass in ARs over cooler SSTs.

- Large delta SST cases are characterized by strong sensible heat loss to the ocean, increased static stability and vertical shear.

- In addition, for large delta SST cases, the stable MBL depth beneath the AR increases along the core and is greatest in the core.

- Weak delta SST cases, in contrast, represent weak decoupling resulting in a less stable boundary layer, weaker low-level jet, and reduced water vapor flux.

Next steps

Accurately representing the complex MBL structure in ‘first-guess’ fields is critical to improving lower atmosphere data assimilation within AR environments

- Perform numerous simulations with multiple PBL schemes; utilize GFS and WRF
- Validate predicted SMBL structure with dropsonde profiles
- Determine which PBL schemes perform best and why
- The end goal is to develop new parameterizations / methods to improve the prediction of complex SMBL structures

Questions