Yen-Heng Li: Causes of recent changes in extreme wildfires in California's South Coast

- Looked at decadal fire cases / area burned by season (in southern California)
- In California (as a whole) area burned has increased, but there is more variability in the South Coast (though the *average* burned area goes up)
- South coast fires are largely due to the Santa Ana winds (high pressure over Nevada) induces warm dry winds winds toward the coast
- Average burned area is related to circulation, which has trended toward conditions which lead to greater fire risk
- Trend toward dryer and windier conditions has led to greater fire risk, despite a fewer number of fires

At the bottom, I am putting notes from the first part of the session: I think the talks fall into five broad categories

- Machine learning / AI
- Predictability of climate impacts (or applications of multi-year predictability to climate impacts)
- Use of internal variability to constrain long-term responses (e.g., via emergent constraints)
- Research disentangling the influence of forcing, internal variability, and climate sensitivity
- Process-based studies of modes of climate variability

White Paper Outline (Patricola)

- **Grand Challenge**: What is the interplay between internal variability (from extreme weather to low frequency modes) and external forcing (both anthropogenic and natural) that affects predictability and prediction of near-term regional climate in decadal climate predictions and what critical processes limit our ability to improve predictability and predictions of multi-year Earth system variability?
- Three main Challenges and areas of Current Research:
    - Multi-year ENSO
    - Atlantic and Pacific Multi-Year Mid-Latitude Variability
    - Prediction and Predictability
- Gaps in Current Research
    - Quantitative understanding of sources of predictability
    - Models' ability to simulate and predict multi-year variability
    - Methods for skill assessment

Sections added based on talks / discussion (Meehl):

- Description of challenges and current research within RGMA
    - Long-term projections
    - Methods other than Earth System models for prediction
    - Internal variability versus forced response
    - Modes of variability

- Gaps in Current Research
    - How to best quantify sources of uncertainty (scenario, model, variability)
    - Evaluation of skill assessment
    - How to better use observational constraints
    - Model order reduction (e.g., linear inverse modeling)
    - Methods to evaluate model variability
    - Identifying effects of AMOC
    - Cause of non-stationary Kuroshio current variability
    - Can predictability of Colorado river supply be applied to crops / fire
    - Need to separate aerosol direct / indirect effects
    - Need to identify why African Easterly Waves are more frequent and stronger in a warmer climate
- Future Goals
    - Better understanding of direct/indirect aerosol response
    - Us AI and machine learning in combination with models and observations to understand forced predictability
    - Focus analysis pathways for improving models (e.g., El Nino bias related to MJO bias)

Items added (based on discussion)

- Description of challenges and current research within RGMA
    - Emergent constraints
- Gaps in Current Research
    - Large ensembles can help explore internal and forced responses
    - Need more reliable observations
    - Need to understand the physical basis of machine learning techniques and their applicability
    - Potential role of the stratosphere for multi-year predictability [Richter]
    - Large ensembles of initialized predictions can be helpful
    - Single forcing experiments (with E3SM) [Lehner]
        - Further analysis would inform whether this is worthwhile
    - Forecasts of opportunity could be further explored (in relation to machine learning techniques)
- Future Goals
    - Assess skill of different techniques (machine learning, linear inverse, earth system models) [Bonfils]
    - Better understanding of forced changes in variability [Bonfils]

PART I Notes

Haiyan Teng: Surface climate decadal predictability

- Can use large ensembles and relative entropy metrics to quantify and compare predictability of both forced and initial-value timescales

Matt Newman: Mining big data to mage global SST forecasts

- Uses analogs from piControl time series to forecast SST changes
- Can quantify model-analog signal to noise ratio to avoid false alarms

Flavio Lehner: Partitioning climate projection uncertainty with multiple large ensembles

- Internal variability is important for near term climate changes
- Larger model uncertainty in CMIP6: likely due to larger spread in climate sensitivity
- Recent (1979 - 2014) warming scales with transient climate sensitivity
- Internal variability and its change is uncertain
- Future: Evaluate modes of variability and their changes

Balu Nadiga: Machine learning as a tool for climate predictability studies

- Models are not yet skillful in near-term initialized forecasts relative to predictions of forced changes
- Models tend to revert to attractors
- Compare linear inverse modeling to other deep learning approaches
- Applied framework to NAO: Machine learning performs better with more data
- Left with question: how much can machine learning help as skill decays rapidly for longer forecasts.

Jiwoo Lee: Are newer climate models better in simulating extratropical modes of variability

- Compares common basis function and traditional EOF approach
- CMIP6 does tend to improve (for spatial pattern); less improvement for amplitude
- AMIP represents a useful experiment for model evaluation

Aixue Hu: Role of AMOC in transient climate response

- Stronger AMOC in CESM2 than E3SM, CESM2 is 0.5 K warmer than E3SM
- CESM has a larger decrease in the AMOC; E3SM has a larger temperature increase
- Heat penetrates deeper in CESM2; more stratification on E3SM
- I believe this stratification leads to greater transient warming?

Yingying Zhao: Removing tropical-extratropical coupled dynamics from North Pacific Climate Variability

- How have ENSO variations contributed to North Pacific variability?
- Want to remove tropical variability from extratropical mode: use a linear inverse model

- Coupled tropical-extratropical variability shows conventional PDO pattern; decoupled system shows ~1/2 as much variance (if I am interpreting plot correctly) and less memory

Youngji Joh: Enhance interaction between Kuroshio extension and tropical Pacific

- Strong connection between Kuroshio Extension and tropical Pacific variability (time period dependent)
- Used linear inverse model, which also shows KE-TP connection is time period dependent (non-stationary)
- Predictability affected by background state

Simon Wang: Colorado River water supply is predictable on multi-year timescales due to ocean memory

- Soil water tracks the Colorado River water supply: gives multi-year predictability
- 3 years of meaningful predictability of water supply
- Predictability largely comes from evolution of low frequency mode changes (via teleconnections)
- Crop yields and burned area track with water supply

Di Chen: Connection between seasonal and future precipitation sensitivity

- Goal: Use relationship between seasonal variability and long-term variability to constrain precipitation efficiency
- Strong relationship in the tropics and subtropics, suggesting a potential monsoon influence

Lu Dong: Correcting the double ITCZ bias dials down future precipitation over the Mediterranean and northern hemisphere

- California has a sharpening of the seasonal cycle of precipitation
- But winter precipitation change has large model spread
- Emergent constraint from double ITCZ index and Southwest/Mediterranean changes
- US Southwest: wet-get-wetter (via larger double ITCZ bias)
- Mediterranean: double ITCZ influential via AMOC bias
- Constraint predicts no change in Southwest and 32% drying in Mediterranean
- Should also look at warming pattern

Celine Bonfils: Disentangle aerosols and greenhouse gases in decadal changes in hydroclimate

- Aerosols AND greenhouse gases are important for decadal variations in temperature rainfall and aridity
- Gaps: Better separation of direct and indirect aerosol effect on climate
- Future: Confirm results with CMIP6 models
- Better understand decadal climate response to aerosol emissions

Jesse Norris: Assessing hydrologic sensitivity in CMIP6 internal variability versus anthropogenic forcing

- Want to constrain forced hydrologic sensitivity with internal variability (emergent constraint)
- In tropics there is a scaling between these metrics (variability and long-term sensitivity)
- PC1 of tropical precipitation looks like ENSO variability and explains tropical mean precipitation

Emily Bercos-Hickey: Anthropogenic influences on African Easterly Waves

- Using WRF configured as a tropical channel model
- Used tracking algorithm of vorticity and compared historical to late-century
- 21% more AEWs in late-century compared to historical
- Greater strength in AEWs in late-century, especially in south track (which is associated with tropical cyclone development)