Two Types of California Central Valley Hot Spells

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1. Background and Motivation

- Prior studies (Grotjahn and Faure, 2008; Grotjahn 2011, 2013, 2014) found that regional scale extreme heat in the California Central Valley (CCV) is linked to Large Scale Meteorological Patterns (LSMPs). LSMPs are an equivalent barotropic, nearly-stationary wave train (ridge-trough-ridge) across the N. Pacific and western N. America.

- **Motivation:** LSMPs vary among individual CCV hot spells (Grotjahn et al., 2014 CESM workshop), so we look closely at the details of every event. Backwards in time trajectories of air arriving at the CCV at event onset find some are mainly from the subtropics for some events while other events are preceded by zonal motion of air from far to the west. Do 2 paths mean two ways to generate hot spell conditions? **We assess the validity of grouping these events into two types of California Central Valley Hot spells and uncover dynamical differences in their LSMPs.**

2. Data and Methods

- **15 NCDC station daily surface Tmax**
- **NCEP –NCAR Reanalyses: 6hourly**
- **Data period:** 34 summer seasons (JJAS, 122days), 1977-2010

- **K-means clustering technique & Pattern projection analysis**
- **Composite analysis**
- **Wave Activity Flux (WAF, Takaya & Nakamura 2001)**
- **Simple backward Trajectories Scheme**

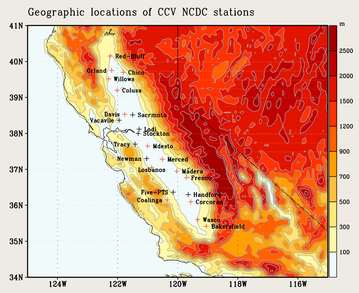

Fig. 1. Geographic location of 23 California Central Valley NCDC stations. Only 15 stations are considered in this study.

3. Hot Spells & Classification

Table 1. 28 hot spells definition and classification

5% hottest days from normalized Tmax anomalies → dates with at least 6 extreme stations →3 consecutive days and minimum 6 interval → 28 events (onset date) total during 1977-2010			
1	"06-05-1977"	15	"08-16-1992"
2	"09-06-1977"	16	"06-02-1996"
3	"06-05-1978"	17	"08-10-1996"
4	"08-05-1978"	18	"08-03-1998"
5	"09-12-1979"	19	"08-30-1998"
6	"07-24-1980"	20	"09-18-2000"
7	"06-11-1985"	21	"07-10-2002"
8	"07-17-1988"	22	"06-22-2006"
9	"08-25-1988"	23	"07-20-2006"
10	"09-03-1988"	24	"07-07-2008"
11	"07-12-1990"	25	"08-27-2008"
12	"08-05-1990"	26	"09-05-2008"
13	"07-02-1991"	27	"09-25-2009"
14	"06-02-1992"	28	"09-27-2010"

Hot spell persistency:
Cluster #1: 4.2days, Cluster #2: 3.8days

28 events are divided two groups based on the dissimilarity of the patterns of U700 (-2day)+T700(-1day)+T600(-2day) over 150W-100W, 20N-60N domain. Five undetermined (mixed) events excluded.

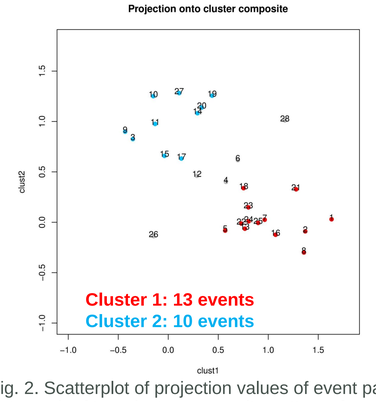

Fig. 2. Scatterplot of projection values of event patterns onto each of two cluster composite patterns for all 28 events. (Red: cluster, #1; Blue: cluster #2)

4. Synoptics & WAF (temporal and spatial evolution)

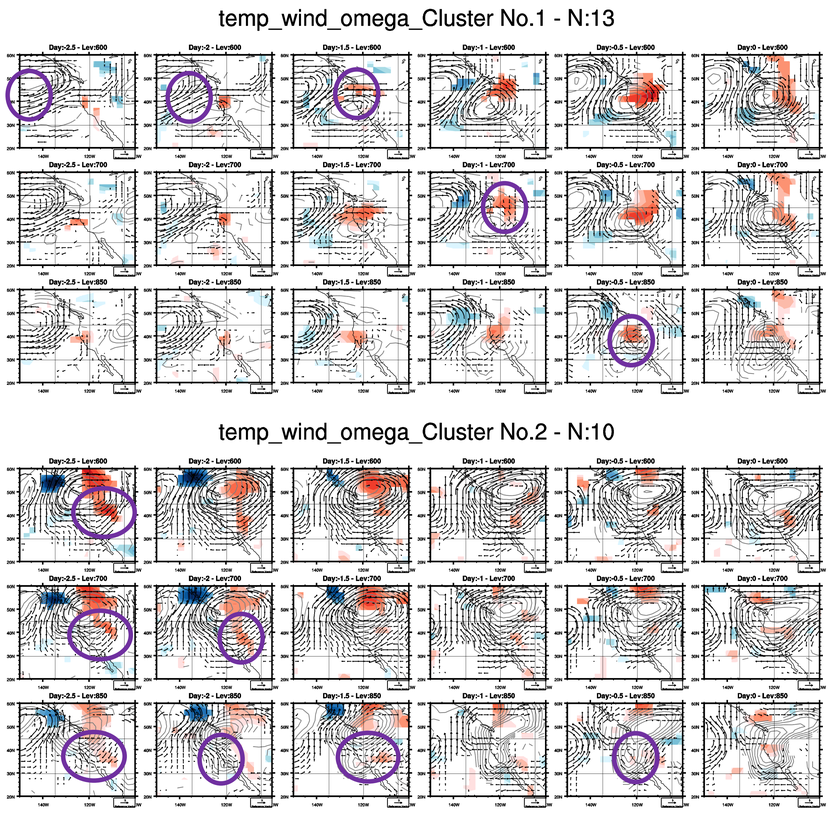

Fig. 3. Composites of anomalies of temperature (Ta, contour), horizontal wind (vector), and pressure velocity (shading) for each cluster. Only grid points where 2/3 of cluster members have the same sign are drawn. **Cluster 1: Anomalous sinking to north of Ta area and anomalous northerly. Cluster 2: Anomalous sinking to east of Ta area and small velocities advection from south and east.**

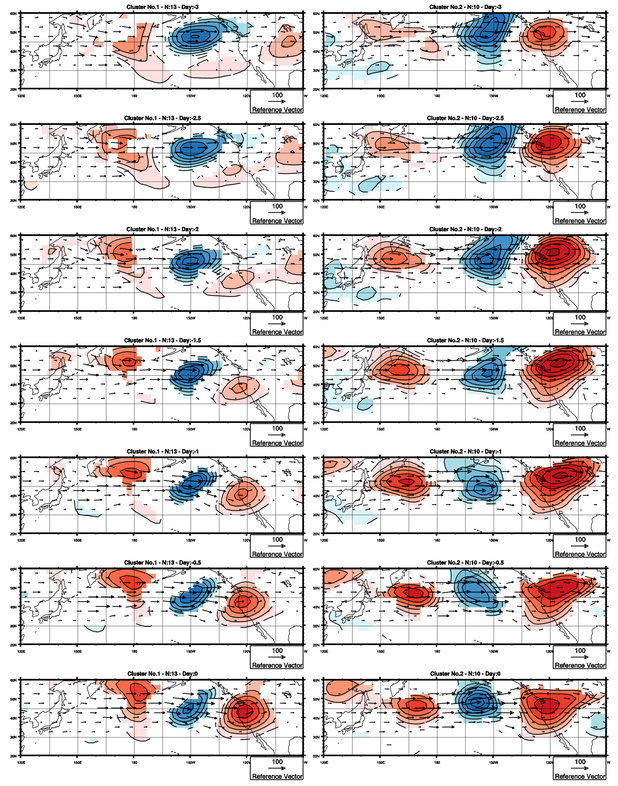

Fig. 4. Composites of geopotential height anomaly (contours) and total horizontal wave activity flux (vectors) for two clusters at 500 hPa. Only grid points where 2/3 of cluster members have the same sign are drawn. **Cluster 1: WAF across Pacific builds ridge at W coast. Cluster 2: Preexisting ridge is amplified on S side by WAF with subtropical origin.**

5. Backwards Trajectories

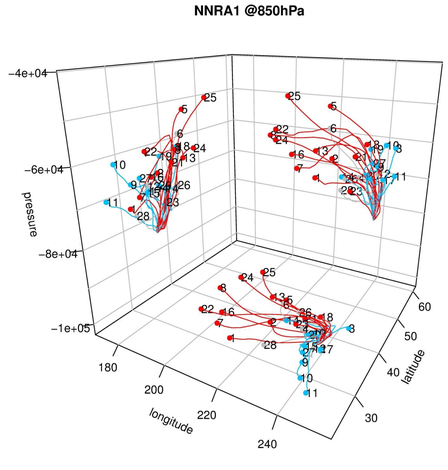

Fig. 5. Backwards trajectories: 2-D projections over 4 days prior to onset for 28 events. Working backwards from area of primary lower troposphere temperature anomaly **Red (Cluster #1) versus Blue (cluster #2)**

Notes:
Clusters have different origins. Cluster 1 often travels across much of N Pacific, while cluster 2 often from desert SW.

6. Conclusions

- ✓ **Most hot spells divide into two clusters based on the evolution of air temperature and zonal wind in low to mid troposphere (fig. 2)**
- ✓ **Composite differences (fig. 3) show formation of primary temperature anomaly area ('Ta area') centered just off CA/OR border. Cluster #1 has anomalous sinking to the north of Ta area that is advected over Ta area as ridge rapidly builds. Cluster #2 has preexisting ridge, sinking well to east of Ta area and small velocities advect from south and east building south side of ridge.**
- ✓ **Cluster #1 develops west coast ridge from WAF across Pacific, mainly from middle/high latitude origin; Cluster #2 develops from preexisting ridge that WAF with middle/subtropical latitude origin builds on southern side of west coast ridge. (fig. 4)**
- ✓ **Trajectories trace the origins of the hot air. Air in Cluster #1 tends to come across Pacific prior to sinking and heat wave onset. Cluster #2 air sinks more gradually with a more local origin.**
- ✓ **Some events mix the two patterns of development**

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