SNOW DAYS? USING CLIMATE FORECASTS TO BETTER MANAGE CLIMATE VARIABILITY IN THE SKI INDUSTRY

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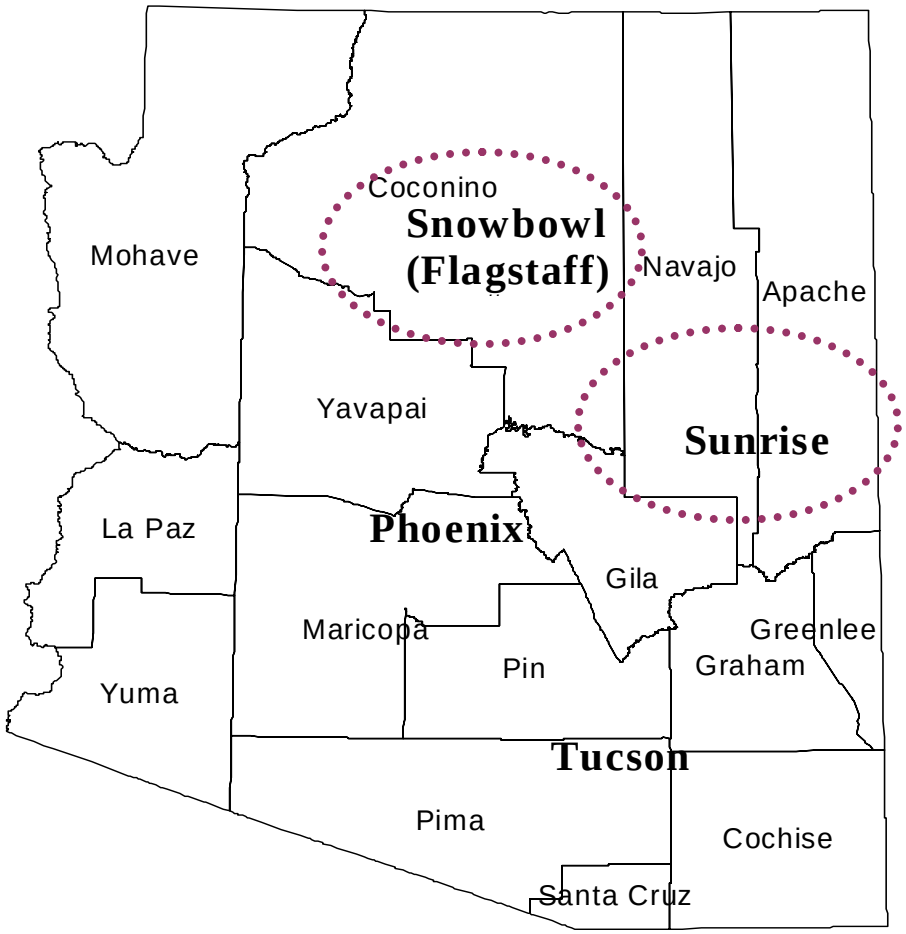
CLIMAS
Climate Assessment for the Southwest

Outline

- Variability of snow seasons
  - Snowfall, season length and skier visits
- Case study
  - High elevation low latitude ski areas in Arizona
    - Snowbowl
- ENSO forecasts
  - Climate Prediction Center (CPC) and National Centers for Environmental Prediction (NCEP)

Arizona’s ski areas



Variability: Snowbowl

- 1982/83-2004/05 seasons
  - Inter-seasonal climate variability
    - Snowfall: 193cm-1,168cm (mean 586cm, S.D. 262cm)
  - Inter-seasonal visitation variability
    - Season length: 4-138 days (mean 92 days, S.D. 40 days)
    - Visits: 2,875-181,000 (mean 105,541, S.D. 56,178)
- Climate Oscillations
  - **ENSO**
  - PDO
- Climate change forecasts

ENSO

- Arizona ski areas are ENSO impacted
  - Model ENSO and snowfall, days open, and skier visits at Snowbowl
    - Natural snow - no snowmaking
- Overall
  - El Niño – good ski season
  - La Niña – poor ski season
  - Neutral – a mixture

ENSO and snowfall

Variable	Parameter estimate	SE	t-value	pr>|t|
Intercept	565.8	49.3	11.49	<.0001
ENSO	125.0	50.9	2.45	0.0225
R^2=0.22				
N=24				

Variable	Parameter estimate	SE	t-value	pr>|t|
Intercept	504.2	59.9	8.42	<.0001
El Niño	246.1	103.7	2.37	0.0268
R^2=0.20				
N=24				

Variable	Parameter estimate	SE	t-value	pr>|t|
Intercept	642.3	61.2	10.49	<.0001
La Niña	-192.4	113.4	-1.70	0.1038
R^2=0.12				
N=24				

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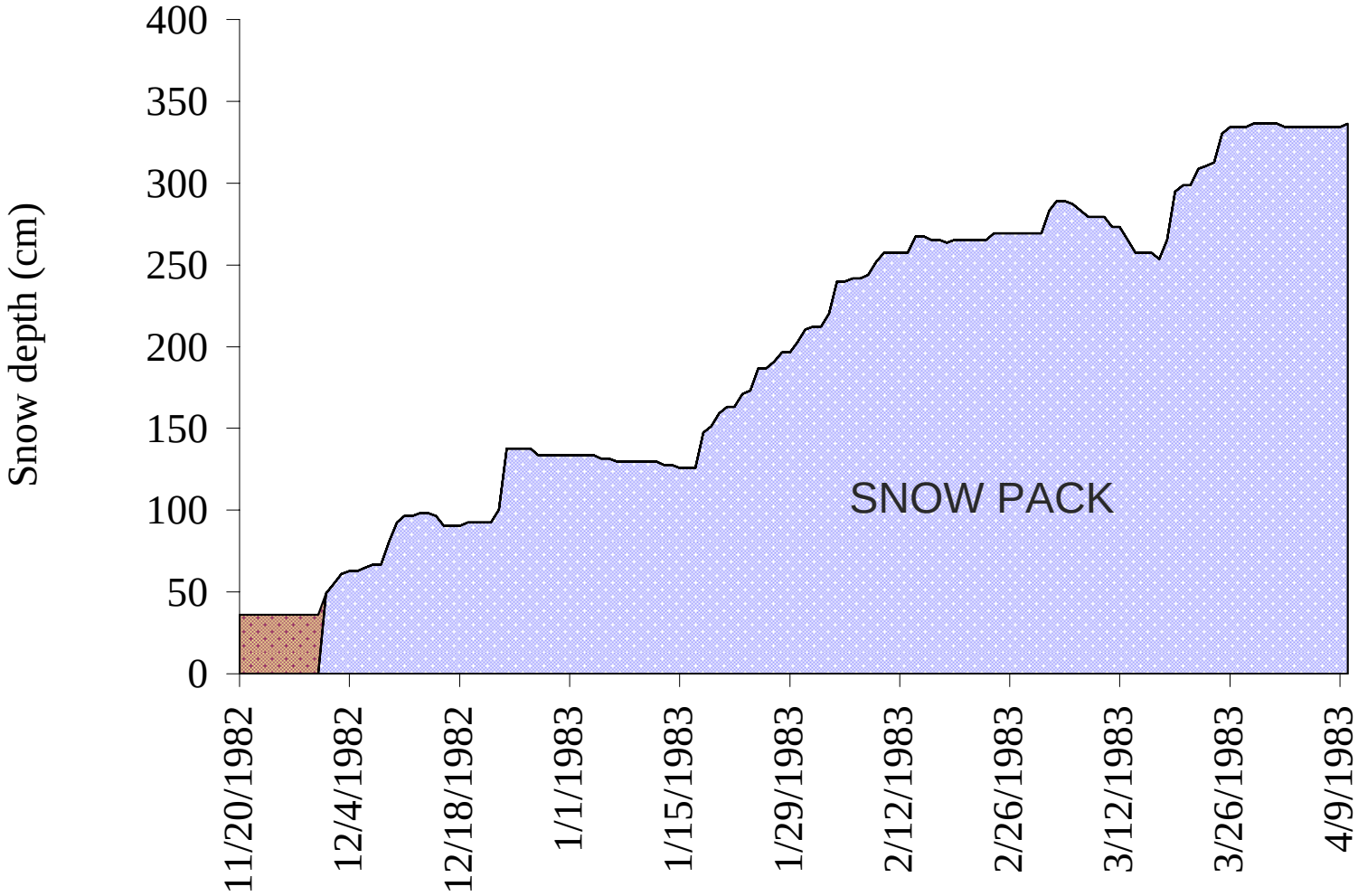
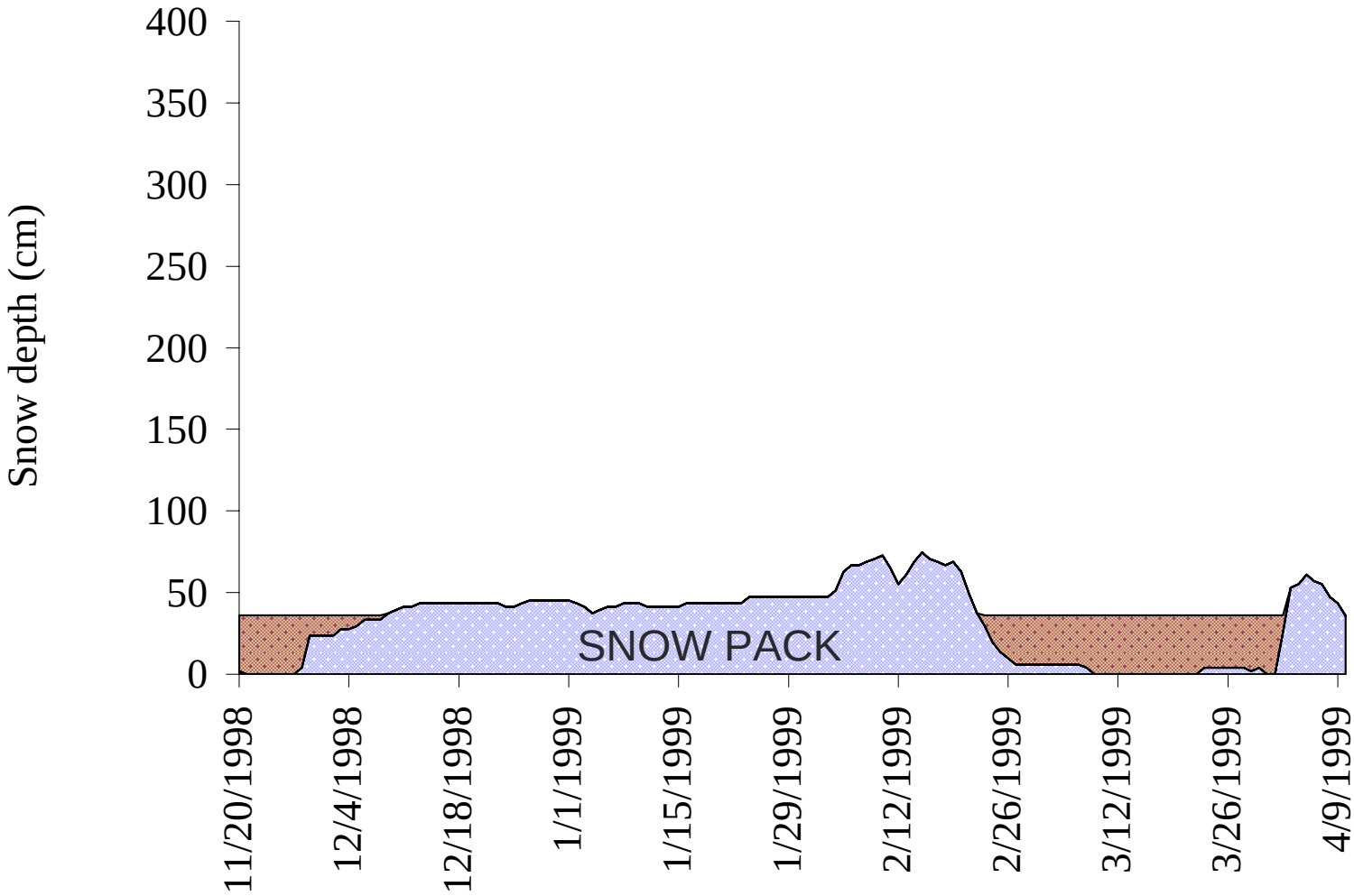
Example El Niño year: 1982-83



Example La Niña year: 1998-99



ENSO and days open

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	89	7.4	12.00	<.0001
ENSO	20	7.7	2.60	0.0162
R^2=0.24				
N=23				

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	80	9.2	8.71	<.0001
El Niño	37	15.9	2.31	0.0304
R^2=0.20				
N=23				

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	103	9.1	11.24	<.0001
La Niña	-35	16.9	-2.05	0.0521
R^2=0.16				
N=23				

ENSO and days open

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	89	7.4	12.00	<.0001
ENSO	20	7.7	2.60	0.0162
R^2=0.24				
N=23				

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	80	9.2	8.71	<.0001
El Niño	37	15.9	2.31	0.0304
R^2=0.20				
N=23				

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	103	9.1	11.24	<.0001
La Niña	-35	16.9	-2.05	0.0521
R^2=0.16				
N=23				

Sunrise: May 5, 2005

Snowbowl: March 3, 2006

ENSO and visits

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	101,257	10,590	9.56	<.0001
ENSO	26,283	10,955	2.40	0.0253
R^2=0.21				
N=23				

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	87,312	12,685	6.86	<.0001
El Niño	54,689	21,970	2.49	0.0209
R^2=0.22				
N=23				

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	117,817	13,061	9.02	<.0001
La Niña	-42,088	24,185	-1.74	0.0958
R^2=0.12				
N=23				

ENSO: Sunrise visits

- Sunrise has snowmaking capability
- Sunrise can modify terrain supply

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	170,237	12,366	13.77	<.0001
ENSO	8,057	10,955	0.64	0.537
R^2=0.04				
N=11				

Omitted variables

- ENSO only explains at most 20% of the variation in total snowfall, days open and visitor numbers

- Days open/visits
  - Number of snow storms, i.e. new snow
  - Minimum snow depth
  - Date of opening and closing, i.e. peak holidays
  - Temperature
  - Conditions at competitor resorts
  - Macro-economics

CPC forecasts

Forecast Evaluation Tool (Beta version). CLIMAS, CAPP, SAHRA, HyDIS, and EOSDIS Synergy. http://hydis6.hwr.arizona.edu/ForecastEvaluationTool/

- Northeastern Arizona region
  - Brier Skill Score Test
    - winter precipitation
    - winter temperatures

- Forecasts Nov-Jan, Dec-Feb and Jan-Mar made in preceding August and September for period 1994-August 2005

- Forecasts made 50% of time for precipitation
  - Test score accurate “wet” 0.197 and accurate “dry” 0.208
- Forecasts made 65% of time for temperature
  - Test score accurate “hot” 0.17 and accurate “cool” 0.429

- Forecasts are often made and are often right
  - El Niño/La Niña forecasts

NCEP ENSO forecasts

- ENSO forecasts
  - http://iri.columbia.edu/climate/ENSO/currentinfo/SST_table.html
  - NCEP Coupled Fcst Sys forecast
    - October, 2005 a weak La Niña
    - November, 2005 a stronger weak La Niña
    - December, 2005 a La Niña

Variable	Parameter estimate	SE	t-value	pr>ltl
Intercept	1,194.9	379.6	3.15	0.0066
El Niño	303.9	124.4	2.44	0.0274
AvgTMax	-100.9	55.3	-1.82	0.0881
R^2=0.39				
N=17				

Economic agents and forecasts

- Mountain managers
  - Hiring decisions
  - Marketing decisions
  - Pricing decisions
  - Estimating snowmaking costs/water consumption
    - Planning timing of snowmaking
- Season ticket purchase
  - Adult $399 up to 9/30 vs. $44: >9 ski days
  - Adult $699 from 10/1 vs. $44: >16 ski days